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A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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Vol. 4 **May, 1921** **No. 5**

EDITORIAL

NEXT ANNUAL MEETING IN ST. LOUIS, 1922

The Twenty-fourth Anuual Meeting of the American Ceramic Society will be held in St. Louis, February 27 to March 2, 1922. To eastern members this may seem far away, but it should be remembered that to reach Pittsburgh, Philadelphia, and even Columbus, has meant long journeys for the westerners.

St. Louis is growing to greater importance as an industrial city every year. It is one of the largest centers for refractories and heavy clay products, while enameled ware, glass, and terra cotta are abundantly represented. Some of the St. Louis members have said that a week of trips for the inspection of plants would be none too long.

The Hotel Statler will be the headquarters of the Society and its facilities for the comfort of the meetings are unexcelled. Large rooms for divisional meetings, with a choice of ball-rooms and banquet-halls for the general sessions, will be available; while the luxury of the private rooms is too well-known to need description.

It will be noticed that the date is later than is customary. The reason for this is that the month of February is buyers' month in St. Louis, and the city is overcrowded without the additional influx of a national convention. The local men therefore urged that the date be put at the very end of the month, and the decision was made in accordance with this advice.

The attendance at Columbus will be hard to equal, but the A. C. S. has never gone backward. If the eastern members will go less than half way to meet the western ones, and the northerners exactly half way to meet the southerners, we shall have the most representative gathering of a decade.

RESEARCH IN CERAMIC DECORATIVE PROCESSES

Before we can properly undertake any consideration of suggestions for research in connection with the decorative side of ceramics, we must have some general idea of what this subject involves. No research work can be undertaken and carried through to completion (so far as this is possible), unless certain fundamentals are recognized and accepted. These fundamentals may be noted as follows: (1) Adequate resources; (2) A clearly defined purpose; (3) Efficient direction; (4) Experienced practical assistance; (5) A well planned equipment; (6) Educational facilities. We will take these points in order, briefly touching upon essential conditions surrounding each item.

1. Adequate Resources.—This condition may be taken in its broadest sense. Financial resources are taken for granted. I refer to all those means, mental and physical, which contribute to the success of an undertaking. Any condition which by its nature interferes with the harmonious progress of a development, and its practical application to the industry is obviously limiting the resources in connection with the activity in question.

Lack of coördination, coöperation, encouragement and appreciation are forces which limit the resources, at least to the same extent as active opposition.

2. A Clearly Defined Purpose or Program.—It will be generally conceded that the ideal condition will be that where the manufacturer and research director are in harmony as to the specific purpose of the activity. The manufacturer could present an outline covering his business policy and give a clear exposition in regard to his particular market, present and future possible competition, demand and supply, future possibilities, and present manufacturing conditions. The research man would then formulate a tentative program dealing with improvements for the

present product, and with developments covering some definite space of time mutually agreeable to all concerned. Such conditions as present manufacturing methods, decorative processes, costs of production, percentage losses, standards, personnel, and essential organization, would be fully covered. In order to ensure a comprehensive discussion which would be the basis of a program for future activities, typical examples of the present product of the concern in question together with sample of domestic and foreign competing wares would accompany the report. Included in the report would be opinions from leading dealers covering present and future possibilities.

With the final program determined, working drawings would be executed and actual samples would be made. Proper recognition would be given to those conditions at present in force. A competent director will commence work with as little disturbance as possible, endeavoring to fit into the organization as its exists, while giving it new impetus. But there is a condition covering all types of product that should be insisted upon, and that is, there should be consistent activity in regard to the development of new methods and processes. The same style of decoration worked out in different ways, produces, of course, different results. Even in such standardized activities as the white ware business there are ample possibilities for development. It is simply a question of whether one prefers to work along the lines of the least resistance, or whether one is out for every rational possibility consistent with practical conditions at hand, and the market requirements.

In due time a well organized research department would have a well stocked museum of completely catalogued and classified productions irrespective of the present needs and demands of the market. In the faience, architectural and art ware markets, the possibilities are limitless. In this country we have architects, artists, draughtsmen, sculptors, and decorators of international reputation, and there is no practical reason why their interest should not be aroused, and their services utilized.

3. Efficient Direction.—A progressive manufacturer with a knowledge of the industrial possibilities should have little trouble in finding men capable of formulating and directing a program

having a specific purpose in mind. But it must be remembered that this is not a one man job. It is a work for an organization, with the program so planned that if the head of the department drop out for any reason the activity will go on without interruption. The main idea, the purpose in mind, must be definite. If the manufacturer is a business specialist, and is conscious of his limitations in connection with artistic matters, he can consult a specialist, just as he would do if he was going to law. The specialist in decorative processes, and the artist or designer would advise him, and if he was capable of convincing him of the business possibilities and could plainly demonstrate a practical program, the manufacturer could feel fairly secure in going ahead. The fact of the matter is, the average business man is afraid of the artist. He calls the artist a freak, balks at his so-called temperament, entirely unconscious of the fact that the average business man is the most temperamental man in the world. An inefficient and incapable decorator will often hide his incompetency by posing as a temperamental person, by ignoring essential practical conditions, and often by displaying contempt for the manufacturer because he is not a specialist in applied decoration. As a matter of fact the average manufacturer knows a lot more about art than the average decorator thinks. The efficient art director and director of artistic research must be an efficient executive with a sound knowledge of business principles, and his work, and the work of his department must be subject to the same rational business treatment and scrutiny and the same discipline accorded to the other branches of the activity.

4. Experienced Practical Assistance.—It has just been stated that one man could not successfully carry out a work under discussion. A symphony orchestra is not a one man activity. An organization for the manufacture of artistic clay products may be compared to the symphony orchestra. The clayworking organization having a decorative department must have its equivalent of strings, brasses, reeds and percussion instruments. And the mere possession of these instruments is not enough. The performers must know how to play. The assistants must be trained specialists. If they are not, the director must teach them, and obviously, they must be teachable material.

We all love beautiful things, but not everyone is equipped to make them. The artist or decorator is not a superior being. He is a human being like the rest of us. But he does, or he should, possess a mental or intellectual makeup which fits him for this class of work. From a business point of view, he is a very important type essential to the success of some of our most important industries. And the sooner our manufacturers learn to recognize this type, the better it will be for all concerned. The art director, and research man must be particularly interested in this type, and insist that all those who enter the art department are above everything else intensely interested in decorative and creative work. There are many factories where the head of the decorating department is a comparatively uneducated, and certainly uncultured foreman subject to authority from the warehouseman or bookkeeper, and who has not the authority to hire his own help. The wages paid in many instances are so low that no-one really interested in an artistic occupation would consider entering this field. The possibilities must be made attractive enough to draw efficient material. At the best, the building up of an efficient organization is no easy task. It is also an expensive undertaking. In my own work, my personal labor analysis chart shows that over thirty per cent of my time is spent in instruction. But it pays. It would pay if it took sixty per cent of my time. An interested and enthusiastic working force is worth any amount of attention. You can not get results without it.

5. A Well-planned Equipment.—The equipment will obviously vary according to the work to be done. In many of the decorative processes the cost of suitable equipment is practically negligible, in fact so small as to be scarcely figured in the cost of production. But the first essential in a well planned department, and most unfortunately, rarely considered by the manufacturer is that relating to the working conditions under which art work is attempted. I am not exaggerating when I say I have seen studios and decorative work shops that are not fit to be used for stables. The modeling, and mold rooms, about the most interesting parts of the plant are usually dirty and disorderly. There is no excuse for this condition. Adequate

lighting and cleanliness would surely seem to be essentials for any type of work, and I do not think I will be accused of drawing upon my imagination when I state that attractive workshops and studios will be conducive to better work, and increased production.

In regard to necessary equipment for development there is often too much indiscriminate buying. The head of the department may be fond of experimenting and dabbling; first trying out one process and then another. If results are not immediately forthcoming a development is dropped, and something else is attempted. Considerable money and effort have been expended, and so far as the result is concerned, there is merely an additional expense to the department. We all have bright ideas which have a tendency to start us off in some new direction, but impulse is not a very permanent productive force. Ideas should be noted and charted for more mature consideration.

If we have a clearly defined purpose, and are working to a definite program, our equipment has been already carefully planned and specified in the orginal report covering the activity at hand. Any requisition for new equipment should be accompanied by a clear report covering the purpose and the development for which it is intended. And any haphazard or unsystematic attitude towards the planning of the equipment, or the actual work of the development should be discouraged. But a well planned equipment is an essential, and it is my experience that very few manufacturers will be niggardly in this regard following a practical demonstration of its productiveness.

6. Adequate Educational Facilities.—This is a big subject, and I have no intention of dealing with it in this paper any further than attempting to outline some of the more essential conditions to be considered.

It is definite that if the manufacturer, the art director, and the director of research in the clay working plants are interested in better artistic products they must take an active interest in the educational side of the work. At the present time the factory is the only place where the student interested in ceramics can obtain a practical training in the various decorative processes used by the potter. I am not referring to the so-called craft or

student work taught in the schools and universities and entirely out of the range of commercial possibility. Yet in these schools there has been for some ten or fifteen years a marked and ever increasing interest in ceramic work. During my twenty years in this country, I have had considerable experience in connection with pottery work as taught in the schools and universities, and I know that there are some hundreds of these institutions who are seriously interested in pottery making and its decoration. This interest should not remain detached. In fact it should be capitalized by the manufacturer. Here is a wealth of material of the highest type for organization and productive purposes open to development if proper encouragement and support is given.

There are many ways of doing this, and the progressive potter does not need assistance in devising ways and means when once he is conscious of the possibilities. It is a lamentable fact that most of our largest pottery centers possess no art or vocational training schools. This condition will of course not always exist, because it is already recognized by forces at present outside the influence of this society and of the pottery manufacturers generally, and it is exemplified by the interest shown in the schools all over the country. But if the potter could be brought to a realization of these possibilities he could utilize these forces to tremendous advantage. As stated previously, this is a big subject and can not be covered within the scope of this present paper. But it is a subject which will have to be dealt with in the near future. Manufacturers and others who have a practical interest in the matter could exchange views, and discuss suggestions offered before some definite program is formulated.

It might be well to state some of the methods employed by the potters of other countries in their efforts to arouse the interest of possible material. In England and on the Continent the manufacturers offer prizes and scholarships to students in the schools who make the best designs, or execute the best work along certain specified lines. These are annual competitions that are followed with great interest. Any factory of average size could well afford to offer such incentive to the students of the local schools, and I believe that if some such idea was ap-

proved by our organization as a body, that a considerable number of the potteries would give prizes and scholarships to students for certain specific works. Such action would result in creating a practical interest, and would be a commencement towards a very healthful coöperation between the industries and the schools. The idea could also be extended to include professionals with some profit. Many English manufacturers obtain some of their most successful designs by offering prizes of sufficient attraction to artists and sculptors of note. I believe also that the American Ceramic Society can be a powerful educational force, especially during our conventions. We meet at least once every year, spend the greater part of our time in discussion of technical papers, but we give little or no attention to the many practical problems of great industrial interest to the manufacturer and the public. I would like to see a convention where the program included the general public. The various manufacturers would submit examples of their products, the schools examples of student work. As far as possible each exhibit would be accompanied with a detailed classification of process. Papers on this day would be of such character as to appeal to the general public, and the educational authorities could be approached in regard to the possibility of a session for the benefit of the local schools. The local papers would be interested and the resulting publicity would be good for our organization. We can not expect to realize the full possibilities for the development of the industry by keeping aloof from that public which is very definitely interested in our activities. Such movements as I suggest will be brought about whether we like it or not. When school children are dabbling in pottery, when independent organizations such as the Apprentice Schools of design, and the Art Alliance are active in this direction, this is evidence of interest which could profitably be coördinated with the interest of the manufacturer.

I am the last man in this Society to belittle the importance of the purely technical man, and when I say that he is simply a cog in a clay working organization, I am only one of an increasing number of pottery men who realize that if the American Ceramic Society is to establish its proper influence in the clay working industries the members as a body must be rationally sympathetic

to those closely allied activities which in turn must be educated to an intelligent understanding of the tremendously important work being done by present day industrial clayworking organizations.

In conclusion, I offer some suggestions for research and general investigation along the lines mentioned. The suggestions are grouped according to the fundamental conditions outlined at the beginning of this paper.

Group One: A Clearly Defined Purpose.—Contributions from manufacturers, decorators, modelers, practical process men, pottery instructors, museum authorities and the layman. Papers and discussions relating to general program for art productions.

Group Two: Adequate Resources.—Papers and discussions defining and outlining specific resources for the production of various wares. A manufacturer may be interested in the production of new types, but he is not familiar with costs and conditions involved. The educational authority may be interested in pottery instruction while lacking knowledge of essential conditions. The ceramist interested in educational work is the man to submit an outline of these conditions.

Group Three: Efficient Direction.—Papers dealing with the organization of art departments, accompanied with discussions of various possible systems of recording and charting experimental work.

Group Four: Experienced Practical Assistance.—Papers outlining specialized activities and giving necessary physical and mental qualifications for each particular field.

Group Five: Adequate Equipment.—Papers outlining complete equipments with costs covering the various processes.

Group Six: Adequate Educational Facilities.—Papers dealing with ceramic instruction, covering various possible systems of apprenticeship, courses of instruction in both the factory or schools, and rational coöperation and coördination between the factories and schools.

This class of investigation would cover plans for the encouragement of pottery work, schemes for exhibitions, and for the

coöperation between other art and architectural organizations. When important art or architectural exhibitions are held, manufacturers, practical men and educators could plan to attend, if not in a body, at least individually, reporting such activities to the head of that division most interested.

Above all, we should not confine our activities to mere talk. Those of us who are interested in progressive development in any industry are usually busy men, a class who prefer to do things rather than talk about them. We are quite prepared to take part in necessary discussions if the discussions produce tangible results. We can not get results without action. Not action from one man, or one particular group of men, but by the properly coördinated efforts of all those forces which contribute to the success of any big undertaking.

The Art Division is, I think, willing to do its share in regard to those activities which meet with the approval of the Society as a body, and it will in due time submit to the trustees a definite program covering such action for the remainder of the present year. It invites suggestions and criticisms concerning points discussed at this meeting, and any other idea which comes to the attention of those interested.

The work will be helped tremendously if it will be possible at future conventions to have a meeting of the heads of the various divisions. The decorative men need the assistance of the technicians, and both these groups can not work without the practical men, and last, but not least, the manufacturer is an official whose attendance is absolutely necessary if we are to get very far with our program.

FREDERICK H. RHEAD

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ZANESVILLE, OHIO

ELECTRICALLY HEATED GLASS ANNEALING LEHR[1]

By E. F. Collins

ABSTRACT

Time-temperature data relating to relaxation of stresses.—Existing time-temp. data covering the relaxation of stresses in annealing of glass has been assembled. Range, control, and distribution of temp. are important factors in annealing. The annealing time was reduced from 5 to 2.3 hours when temp. var. was reduced from 10° to 2.5° C, in the case of one glass whose annealing temp. was 476°.

Electric heat secures perfect anneal in shortened time.—Electric heat with its automatic control holds temp. within +0.6 per cent in ranges required for annealing, as shown by tests, even when the temp. changes 23° per hour and when the annealing treatment (as for optical glass) covers a month in time.

Vertical Lehr superior to horizontal type.—Electrically heated lehrs of horizontal and vertical types are discussed. The vertical lehr offers many apparent advantages and a higher thermal efficiency. A particular lehr of 500–600 lbs. ware capacity per hour, shows efficiencies in ratio of 6 to 10 in favor of electric lehr of vertical type. Tests made on an electrically heated vertical lehr annealing high grade ware showed a reduction in cost of manufactured part of 20 per cent, or more than 75 times total cost of electric power consumed.

In suggesting the use of electric heat for glass annealing lehrs, the writer of this paper is not unaware of the indefiniteness and scarcity of published data covering the conditions necessary for satisfactory and uniform anneal of a specific type of glass. Data presented in this paper is in nowise original; the writer has drawn freely from published reports.[2] He recognizes that this process is one of the most delicate in the manufacture of glass; and that the actual annealing procedure for one type of glass varies widely from that of another. On the other hand whether glasses differ in composition, and whether they be used for industrial and domestic purposes or optical and scientific work, the problems involved in the heat treatment or annealing procedure necessary to meet service requirements and specifica-

[1] Received February 21, 1921.

[2] Bureau of Standards' paper No. **358,** also Rosenhain, Williamson and Roberts, Tool and Valasek, and W. M. Clark.

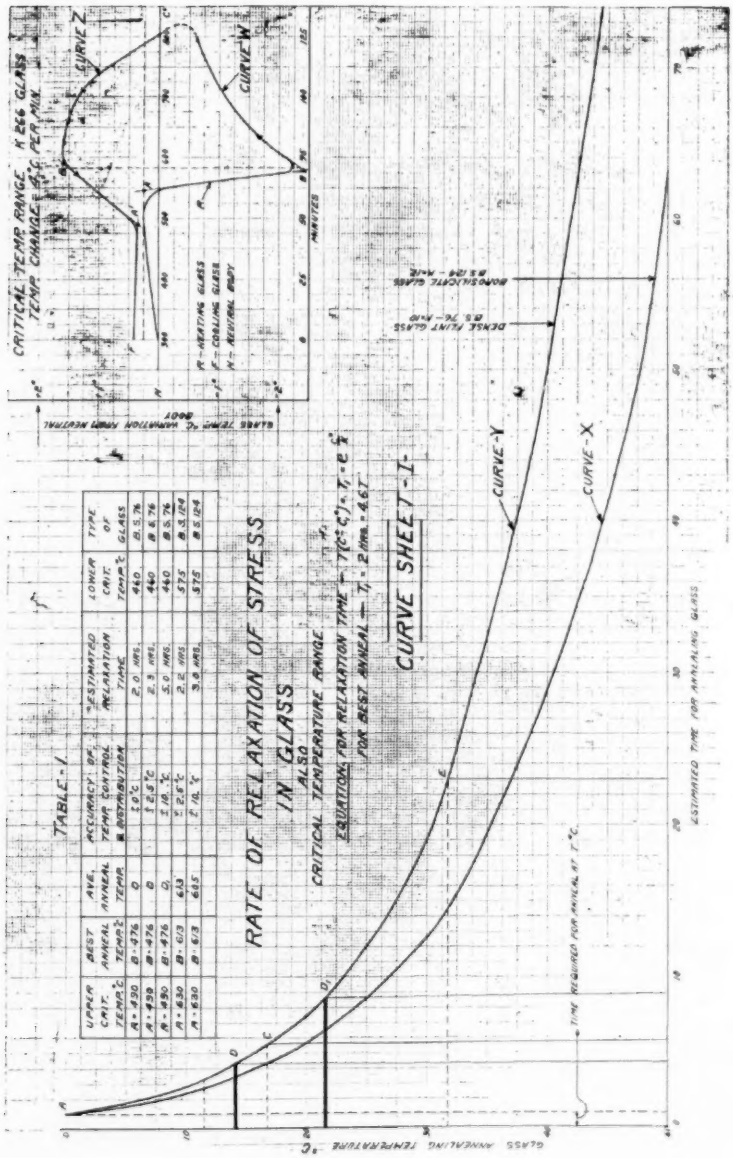

CRITICAL TEMP. RANGE
TEMP. CHANGE 85°C. PER MIN.
CURVE Z
CURVE W
GLASS TEMP. °C. VARIATION FROM NEUTRAL SPOT
R = HEATING GLASS
C = COOLING GLASS
N = NEUTRAL SPOT
MINUTES
RATE OF RELAXATION OF STRESS IN GLASS
ALSO
CRITICAL TEMPERATURE RANGE
EQUATION FOR RELAXATION TIME $= T(e^{\frac{1}{T}(t_2 - t_1)} - e^{\frac{1}{T}t_2})$
FOR BEST ANNEAL $= T_1 = 2$ min. $= 4.6T$
CURVE SHEET -I-
CURVE-Y
CURVE-X
DENSE FLINT GLASS
B.S. 76 - MAR
BOROSILICATE GLASS
B.S. 124 - MAR
TIME REQUIRED FOR ANNEAL AT t °C.
ESTIMATED TIME FOR ANNEALING GLASS
GLASS ANNEALING TEMPERATURE °C

TABLE-I

UPPER CRIT. TEMP. °C	BEST ANNEAL TEMP. °C	AVE. ANNEAL TEMP.	ACCURACY REQ. TEMP. CONTROL & DISTRIBUTION	ESTIMATED RELAXATION TIME	LOWER CRIT. TEMP. °C	TYPE OF GLASS
A-490	B-476	0	±0°C	2.0 HRS.	440	B.S. 76
A-490	B-476	0	±2.5°C	2.3 HRS.	440	B.S. 76
A-490	B-476	0	±10.°C	5.0 HRS.	440	B.S. 76
A-630	B-613	613	±2.5°C	2.2 HRS.	575	B.S. 124
A-630	B-613	685	±10.°C	3.0 HRS.	575	B.S. 124

Fig. 1.

tions are in general very much the same, whether the annealed product be judged by the sensitive polariscope, or "strain viewer," or by simple tests such as pouring hot water into fruit jars, "bump" and "drop" tests, or the testing of bottles by a sharp rap from a hickory stick in the hands of an inspector educated in its use.

Ordinary glass ware is considered to be sufficiently annealed when stresses as great as 5 per cent of the breaking stresses are present. However where double refraction must be eliminated, or where change of form due to slow relaxation of stresses is objectionable, as in optical instruments or thermometers, further

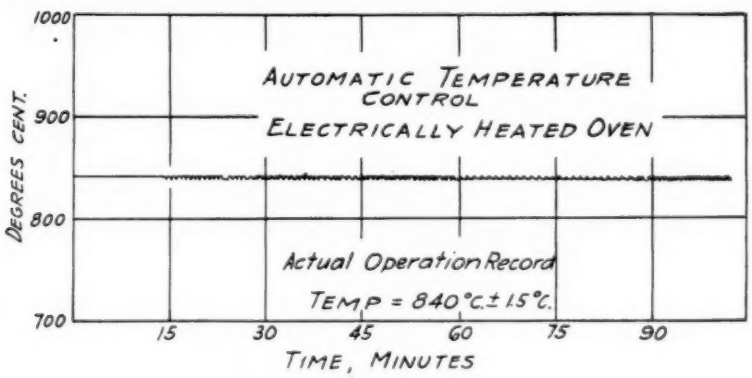
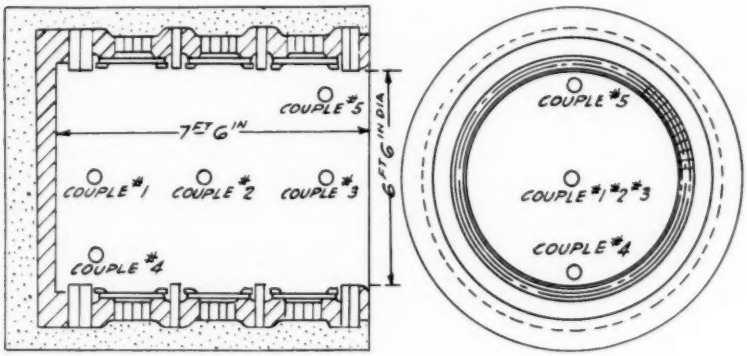


FIG. 2.

reduction of stresses are necessary. A piece of fine annealed glass, 8 inches in diameter suitable for a telescope lens, gave only one-third the retardation of a normally annealed plate.

In all glass annealing, it is of vital importance that the temperature of the glass mass should be uniform in the annealing range. Temperature gradients in the mass of homogeneous glass under treatment, are solely responsible for the setting up of strains. These gradients may result from too great speed of cooling, as well as from a non-uniform and unsymmetrical heat distribution. Hence the importance of heat control with respect to time and also proper heat distribution in the annealing lehr through which the ware is passing. Likewise where glass is treated in the box type oven, it is extremely important that the heat distribution of the oven be correct and that the heating

equipment lend itself to the exact following of the time temperature cycle desired, what ever that may be, *i. e.*, annealing cycles covering a few hours and those covering a month should be equally accurately followed no matter what the temperatures and the rates of change required throughout; and preferably such temperature time control should be automatic and should correspond to a predetermined cycle.



TIME	THERMOCOUPLES - TEMP °C.					AVER TEMP	PER CENT DEVIATION FROM AVERAGE		RATE OF CHANGE
	1	2	3	4	5		ABOVE	BELOW	DEG. PER HR
11 30	25	25	25	25	25	25	0	0	
3 30	527	537	532	530	545	534	2.07	1.31	127°C
7 30	670	679	671	666	669	669	1.5	.45	34
11 30	777	783	776	766	780	776	1.0	1.3	27
3 30	858	864	857	849	864	860	.46	1.3	21
7 30	860	865	862	862	863	862	.35	.23	0
11 30	928	934	930	930	928	930	.43	.21	17
3 30	933	932	927	925	927	929	.64	.43	0
4 30	950	950	952	952	955	952	.31	.21	23

FIG. 3.—Test data of heat uniformity of electric furnace.

The importance of exact temperature control at least from the economic point of view, is illustrated by Curve Sheet I (Fig. 1), which in general shows the change in annealing time with the temperature of anneal. Suppose the point D, for a flint glass is the best temperature point to anneal in two hours time for ordinary purposes, say where stresses are reduced to $^1/_{10}$ the breaking value. Assume an automatic temperature control

of 476° ± 2.50°C, then the actual time for anneal at the average temperature of 476°C is 2.3 hours as against 2 hours at 476°C with perfect control. Again assume a less close control, *e. g.*, one whose variation is ±10°C. Then the average anneal would occur at D_1 or about 468°C and a total relaxation time for safety corresponding to temperature E, or about 5 hours. Here due to the difference in sensitiveness of heat controls we have doubled the length of time for the anneal and undoubtedly for the greater part have an inferior glass product.

An automatic temperature control within ±2.5°C is available if electrically heated annealing lehrs of proper design are used. The variation of ±10°C is usually a fair measure of non-uniform or unsymmetrical temperature distribution and control met with in the fuel fired lehr operating at such temperatures as 475°C.

As an illustration of what may be accomplished in temperature control in electrically heated ovens, attention is called to the time temperature curve in figure 2. This is a curve record of an actual performance which holds temperature constant within 0.3 of one per cent.

An example of temperature distribution is given in figure 3 and its accompanying table. It will be noted that for a rising temperature of 125° per hour, only one point varies from the mean temperature by 2.07 per cent. With 35° change per hour, the variation from mean temperature is 1.5 per cent maximum while with the temperature changing at the rate of 17° per hour, the maximum deviation from mean is only 0.43 per cent, and at constant temperature, *viz.*, at 860° maximum variation is 0.35 per cent and at 930° the variation is 0.64 per cent in an oven 6 ft. 6 inches diameter and 7 ft. 6 inches deep. Such control and distribution of heat as the above, should, it would seem, meet the most exacting requirements of any and all types of glass annealing, including the fine annealing of large lenses for telescope work.

Curve Sheet III, figure 4, shows the time temperature cycle required in the "fine anneal" of a crown glass lens for telescopic purposes. Such a process is best carried on in the box type of lehr, figure 5 in which the lens is placed and subjected to a tem-

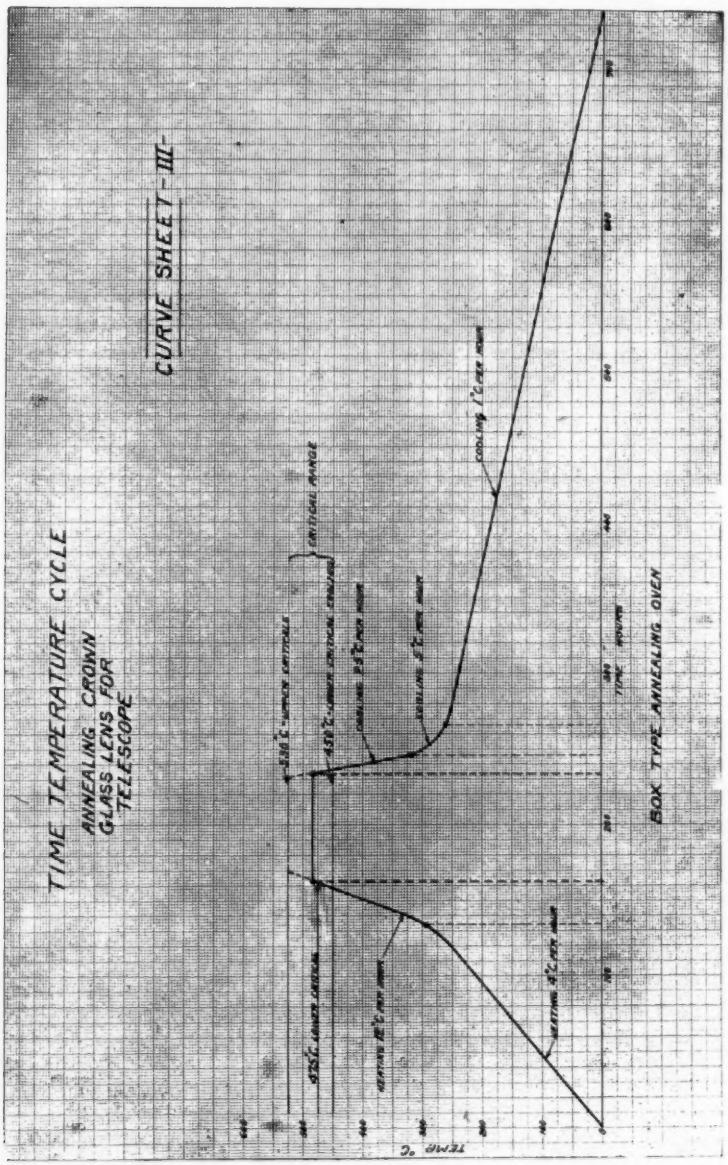

TIME TEMPERATURE CYCLE
ANNEALING CROWN GLASS LENS FOR TELESCOPE
CURVE SHEET - III -
BOX TYPE ANNEALING OVEN
CRITICAL RANGE
TIME HOURS
TEMP °C
GENERAL ELECTRIC COMPANY SCHENECTADY N.Y. U.S.A. (METRIC DIVISION)

FIG. 4.

perature cycle as shown. Automatic control is available together with electric heat whereby this particular cycle or any similar one may be followed and repeated exactly whenever desired. The control instrument is operated by a time keeping motor supplemented by a simple cam arranged to give different rates of heating or cooling according to a predetermined characteristic such as shown on Curve Sheet III, figure 4. Certain tests for fine anneal with this type of apparatus have been made and our reports thus far seem to indicate that results may be obtained that have not been realized in any other method of annealing. Results are not the product of chance but may be duplicated repeatedly due to well nigh perfect distribution coupled with an absolutely positive and dependable automatic control of the temperature time cycle.[1]

Curve Sheet II, figure 6, shows the characteristics suited to the annealing of a large part of the glass ware in use for domestic and industrial purposes. These curves are built up from data on Curve Sheet I, which carries in general data regarding critical points and relaxation time which must be observed in arranging for successful anneal. Here it is assumed that the stresses are reduced to at least $^1/_{10}$ of those which will produce rupture of the glass ware. The two curves in figure 1 show how the relaxation[2] time varies with different glass compositions.

Returning now to Curve Sheet II, figure 6, the two heavy curves represent the annealing cycles which glass receives in a conveyor type lehr when the temperature control is $\pm 5°$ (Curve X), and when the temperature control is $\pm 15°$ (Curve Y), respectively, figure 7, shows the ordinary commercial lehr, with conveyor, and fitted with electric heat, and which when equipped with automatic control will readily give temperature cycle (Curve X), Curve Sheet II, required for a particular glass; this annealing period totals three hours and 20 minutes. This time includes heating up from 400°C to 590°C, the necessary relaxation time 5 minutes and safe cooling time three hours from 585°C to 375°C

[1] See the New York Tribune, Sept. 15, 1920, for news bulletin of the American Chemical Society in which successful operation of electric furnace to the annealing of telescope discs by Geo. W. Morey, is announced.

[2] For table showing critical range for several specific glasses, see Bureau of Standards, *Technical Paper* No. **358**.

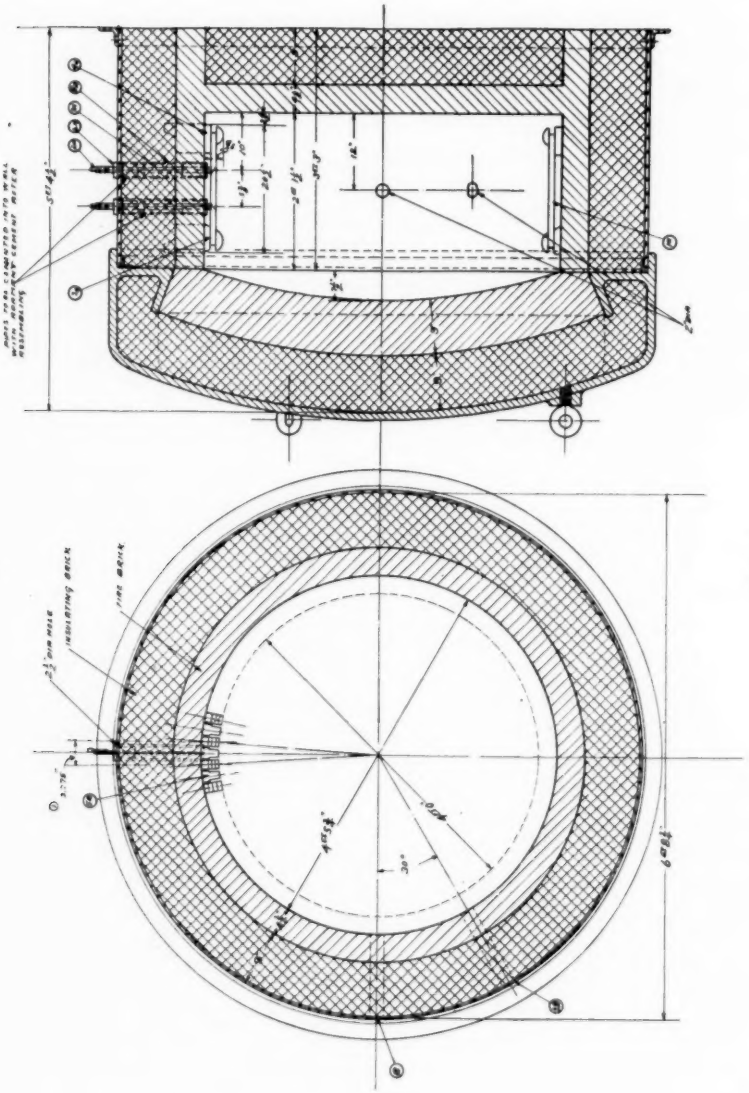


FIG. 5.

where it may be exposed to the air. Were the lehr, figure 7, of the usual fuel fired type, the glass would necessarily be subjected to a cycle comparable with Curve Y, due to non-uniformity of heat distribution and wider range of control. The output would be less uniform and dependable than glass subjected to the much shorter cycle, Curve X. In other words, the complete cycle length embracing the same temperature stages is 8 hours and 15 minutes for Curve Y, as against 3 hours 20 minutes for Curve X; a reduction of about 60 per cent in length of anneal in favor of the electrically heated lehr. In other words, the electric lehr should handle easily twice the ware of the fuel heated lehr when introducing and removing the ware from the lehr at the same temperatures, *viz.*, 400°C and 375°C.

While positive tests are not yet available to prove the correctness of the above reasoning, indications are that they will be realized in a lehr designed to take full value of the advantages inherent in the electric heat and its perfect control.

From the standpoint of the electric heating engineer, a glass lehr design, shown in figure 8 embodies many advantages for rapid, uniform and economic annealing of most commercial glass. Among its possible advantages are the following: (1) high thermal economy, (2) heat distribution easily secured, (3) small floor space required, (4) may be located near fabricator and receive ware at higher temperature, (5) reduction in labor, (6) no opportunity for ware to absorb products of combustion, (7) low temperature gradient, (8) heat control, —2.5°C may be secured automatically, (9) annealing time less than one-half that required by present day fuel fired lehr, (10) practical elimination of rejects, distortion, and breakage due to heat treatment, (11) no sulphuring of the ware occurs and the product has a bright polished surface requiring no subsequent cleansing or washing, (12) the ware is sterile and absolutely clean as all microbes are destroyed by heat so that for prescription ware, this feature has importance as medicinals can be filled in and sealed immediately after leaving the lehr.

Specific conditions would no doubt call for a modified design over that shown in figure 8, but it is presented here to call attention to some advantages which ought to be realized with this general type in commercial annealing.

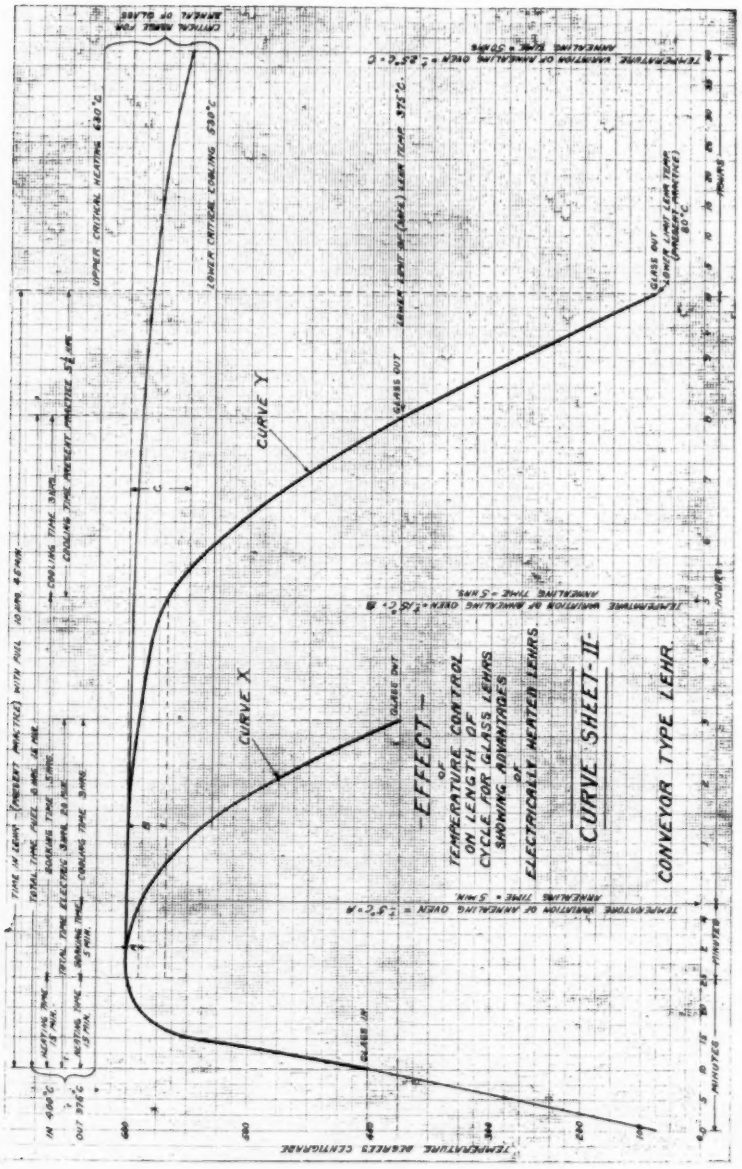

CURVE X
CURVE Y
EFFECT OF TEMPERATURE CONTROL ON LENGTH OF CYCLE FOR GLASS LEHRS SHOWING ADVANTAGES OF ELECTRICALLY HEATED LEHRS.
CURVE SHEET-II-
CONVEYOR TYPE LEHR.
GLASS IN
GLASS OUT
UPPER CRITICAL HEATING 630°C
LOWER CRITICAL COOLING 530°C
CRITICAL RANGE FOR ANNEAL OF GLASS
TEMPERATURE MEASURED CENTIGRADE
MINUTES
HOURS

FIG. 6.

Exact operating costs for electrically heated lehrs are not yet available, but several estimates made for commercial work are being realized and in some installations, there are large savings in favor of electric heating, when overall costs, quality, increased production, and elimination of rejects are taken into account. The heavy conveyor type of lehr of present day usage, with its very great heat absorption or capacity and low thermal efficiency, which disqualifies it for best results of electrification, gives an efficiency when equipped with electric heating of six lbs. of glass ware per kw. hour. The estimate for the vertical type described above, electrically heated, is 10 lbs. of glass per kw. hour. These figures are based on ware entering lehr at about 900°F and being raised to temperature not above 1200°F. The horizontal lehr used for above calculations occupied a floor space of 70 ft. by 10 ft. and height of 10 ft. with a glass capacity of 600 lbs. per hour. The vertical lehr would occupy a floor space of 18 ft. by 21 ft. and its rated capacity would be 500 lbs. of ware per hour. The connected electric load of the vertical lehr would be 60 kw. as against 125 kw. for the horizontal type.

An electrically heated vertical lehr and which replaced a gas heated lehr has now been running for several months on a high grade glass ware and reliable overall factory costs have been made up for the annealed part. These factory costs show a decrease per unit annealed of 20 per cent or a cost of but 80 per cent of the former cost when annealed in gas-heated lehr. The saving was about 75 times the total cost of power for heating lehr.

In conclusion, while the writer appreciates that the logical development of annealing by electric heat, and certain assumptions in this paper may be at variance with, if not contradictory to, certain phases of established practice, he himself is thoroughly convinced that the soundness of the proposition has been fairly well demonstrated by the careful experiments reported by the Bureau of Standards, the Geophysical Laboratory, and the University of Sheffield, England, not to mention those conducted in our own laboratories, and supported by some satisfactory practical demonstrations with production lehrs. The writer urges that serious consideration be given the electric lehr by

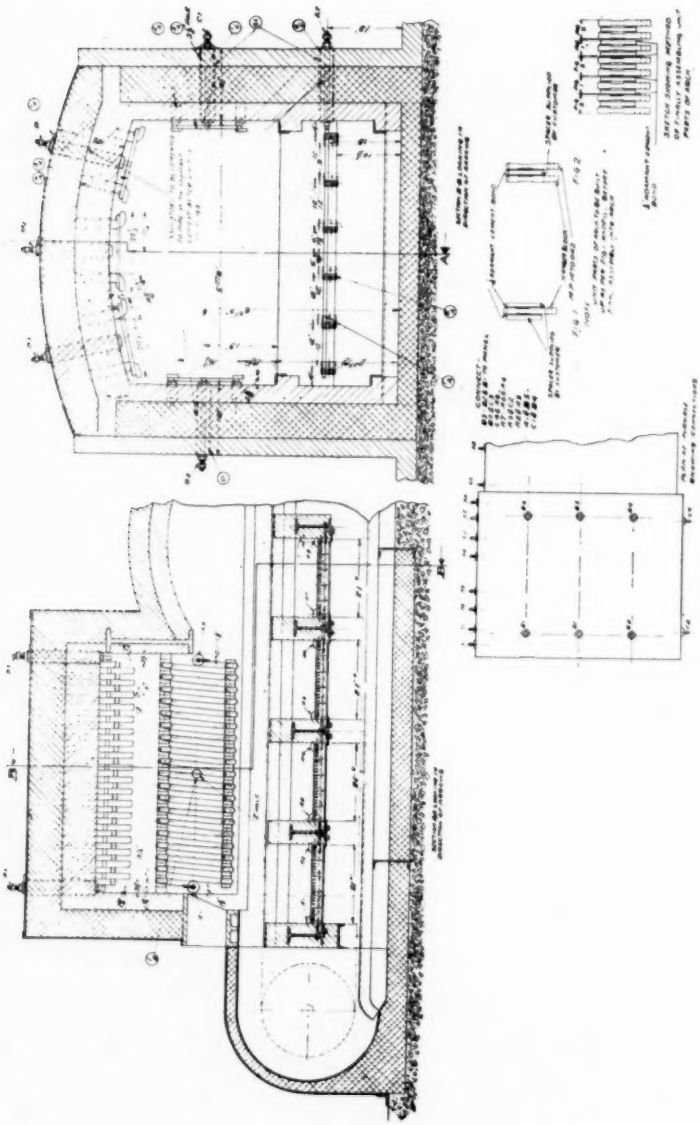


Fig. 7.—Assembly of ribbon resistor furnace.

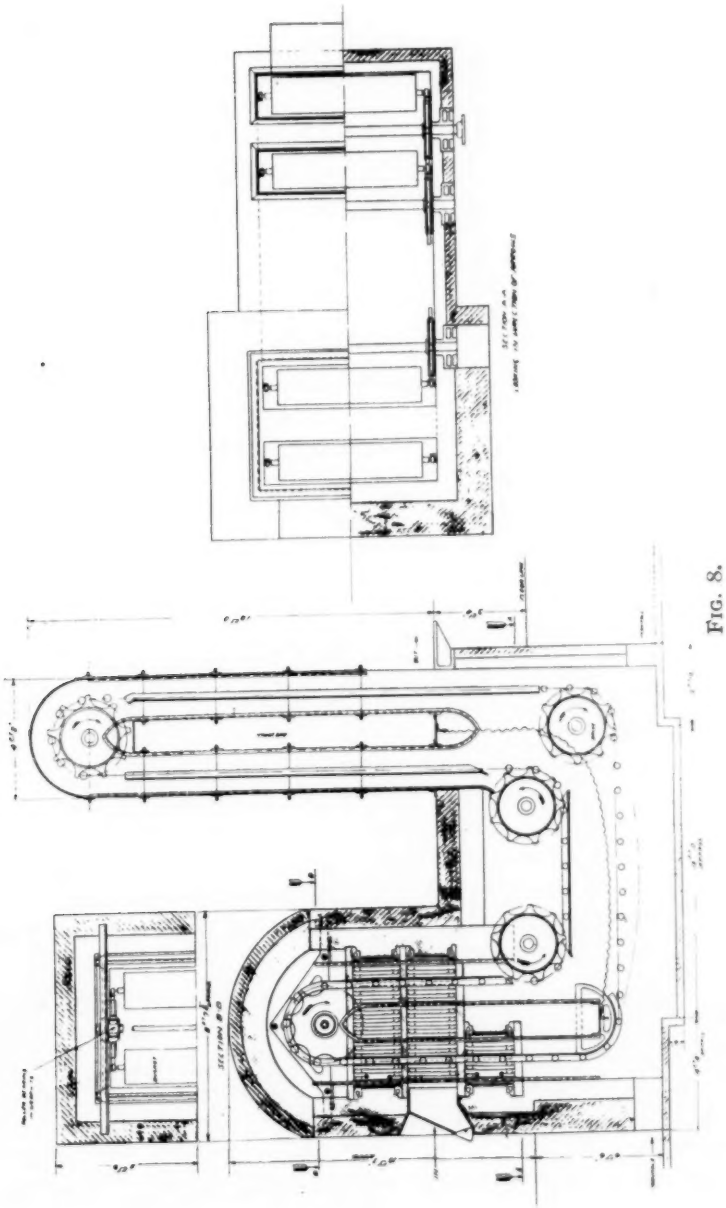


FIG. 8.

glass manufacturers, with the full confidence that its installation and use will demonstrate the claims of superiority and result in the standardization of such equipment for annealing glass.

INDUSTRIAL HEATING DEPARTMENT
GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

Discussion

L. H. ADAMS: To one who is interested in glass-annealing it is very gratifying to observe the progress made by Mr. Collins in developing electric annealing furnaces. The electric heated lehr is without doubt the ideal equipment for the purpose. A temperature constant within 2° or 3°C and uniform over the whole interior to within the same amount; the ease with which the temperature can be automatically controlled so as to follow any desirable time-temperature curve; low operating costs; uniform quality of annealing—all these indicate the superiority of the electric furnace as compared with the gas-fired equipment.

In working out actual annealing schedules, however, it would seem that Mr. Collins has not taken advantage of the most recent data on the annealing of glass. The most advantageous annealing schedule can not be determined solely from observations of the "critical ranges" for the various kinds of glass. It is necessary to have a complete set of data on the annealing-times for various temperatures. Furthermore, it can be shown that the best annealing schedule requires that the annealing-time be equal to the cooling time; that the glass be cooled at an increasing rate; that thick pieces be annealed at lower temperatures than thin pieces; and that the total time required is proportional to the square of the thickness. The time-temperatures given by Mr Collins show the glass to be cooled at a *decreasing* rate even at the higher temperatures.

The "best" annealing temperatures for "dense flint" glass (Bur. Stds. No. 76) is given as 476°. This is probably too high, since any kind of flint glass of reasonable thickness should not be annealed at a temperature higher than 430° (cf. *J. Franklin Inst.* 190, 852 (1920)). The schedule for a crown glass telescope lens as shown in "Curve Sheet III" indicates that a total of 700 hours would be required for the annealing process. Now the

largest lens blank ever made in this country is six inches thick, and a piece of glass of this thickness should not require more than 300 hours for a very complete annealing. Similarly the schedule according to which commercial glass requires 3 hours is probably too long. The total time of the annealing process for thin glass ware could be reduced to little more than one hour.

Author's Closure.—I am gratified that Mr. Adams points out that the most recent data on the annealing of glass defines further, important conditions that work toward shortening the annealing cycle. This means that when the electric lehr is in the hands of the glass manufacturing expert, who can apply the most advantageous anneal schedule in every case, the limit of its accomplishment will be much in advance of the claims made in my paper.

SOME DATA ON THE COMPOSITION OF ARSENIC ENAMELS FOR COPPER[1]

By B. T. Sweely

ABSTRACT

Methods of application are by usual wet slushing, and sieving powdered enamel on to clean copper sheets and fusing to a smooth coat. Where slush-coat is necessary it is advisable to use an enamel free from lead and arsenic as a ground. In this work the dry method is used exclusively. In the formulae given, increase of SiO_2 increases fracturing or shivering, increase of B_2O_3 above 0.2 equiv. in presence of 0.1 equiv. As_2O_3 causes enamels to come mat. Increasing KNaO at expense of PbO decreases opacity, improves fit and gloss, but makes enamel more soluble. The following limits in composition are recommended: 0.3 to 0.7 KNaO, 1.3 to 1.8 SiO_2, 0.7 to 3 PbO, 0.0 to 0.2 B_2O_3, 0.05 to 0.15 As_2O_3.

The data on the type of enamel presented below were secured by the writer in an investigation of arsenic enamels for copper. No attempt was made to cover the field of all possible compositions nor the allowable limits of different materials, the purpose in mind being the gathering of sufficient data to produce a suitable and workable enamel for the particular job under consideration. This work was of such a nature as to require an enamel very similar to a watch dial enamel in appearance and application, but it was necessary to apply it in a much heavier coat than is the usual practice on dial work.

There are two methods of application of enamels of this type in use commercially—one is the usual method of wet grinding and applying as a slip—the other of sieving the dry powdered enamel on to the clean copper sheet and firing in the usual manner. In this work the latter method was used exclusively as it was best adapted to the work in hand and eliminated the necessity of adding clay and setting up agents to the enamel slip. When it is desired to enamel both sides of a shape or one with vertical surfaces, the wet method is, of course, indispensable. In such cases it has been the writer's experience that the best results

[1] Received March 19, 1921.

are secured by applying a ground coat free from lead before putting on the lead-bearing arsenic enamel, due to the ready attack of the copper by lead enamels when applied in thin coats, resulting in a disagreeable green color in spots unless the pieces are very evenly dipped.

The formula of a ground coat with which good results were secured on thin copper sheet is given below:

GROUND COAT FOR COPPER

$$\left.\begin{matrix} 0.15\ K_2O \\ .55\ Na_2O \\ .20\ CaO \\ .10\ BaO \end{matrix}\right\} 0.15\ Al_2O_3 \left\{\begin{matrix} 1.8\ SiO_2 \\ 0.4\ B_2O_3 \end{matrix}\right.$$

Materials	Equiv.	Batch Wts.
Feldspar	0.15	83.5
Soda nitrate	.10	17.0
Soda Ash	.45	47.7
Whiting	.20	20.0
Barium Carbonate	.10	19.7
Boric Acid	.40	49.6
Flint	.90	54.0

Milled with 5% Clay and 10% Tin Oxide.

A search of the available literature yielded but little information on the type of enamel in mind. Minneman[1] reports some very good work on Cloisonne enamels using a clear leadglass, while Randau's "Enamels and Enameling" gives some data on the manufacture of watch and clock dials with tin enamels, but only the former's work proved to be of any value in this study.

That arsenic is a good pacifier for glass and enamel is, of course, well known, and for the production of densely opaque and very white enamels it is almost indispensable. Due to the poisonous nature of its compounds and its ease of volatilization, however, it is but little used except for those classes of work where its use is necessary to secure a certain quality of whiteness and opacity in the finished enamel. Preliminary experiments led the writer to believe that an arsenic enamel was best fitted to the work in mind, and the following study was planned in order to secure the necessary data from which to develop an enamel

[1] *Trans. A. C. S.*, **13**, 514.

of the desired opacity, color, etc. The materials used were of ordinary ceramic grade, and as they were of about the same degree of purity as would be obtainable for manufacturing purposes, no analyses, etc., were made on them. The enamels were weighed out in gram formula weights and checked by weighing the total batch. They were then thoroughly mixed by sieving and smelted in a small crucible gas furnace until a thread of glass drawn from the metal was free from knots, quenched in cold water, dried, and ground in a small porcelain jar mill to just, pass fifty mesh. The copper trials were No. 16 stock 2″ square, and were cleaned by dipping in dilute nitric acid, washed in clean water and quickly dried. The powdered enamel was then sieved onto the clean copper in a coat heavy enough to secure the desired thickness of enamel and fired in a small electric furnace. No data on firing will be included since any enamel firing operation depends so largely on weight of metal, number of pieces in heat, etc., that it is of little value at best, but in general it may be said the enamels all matured at from 850°C to 900°C.

The trials were examined for opacity, luster, fit, and their firing behavior observed, *i. e.*, whether or not they flowed out readily to form a smooth uniform coating on the copper. The fit was judged by the tendency of the enamel to "fracture" in cooling.

The first series studied was with the addition of silica to a base enamel, which was essentially a mean of the hard and soft fluxes recommended by Minneman,[1] to which 0.1 equiv. As_2O_3 and 0.15 equiv. B_2O_3 had been added. In this series, the RO, As_2O_3 and B_2O_3 were maintained constant and the SiO_2 increased in steps of 0.1 equiv. as shown.

Series I

	Molecular Formula					
Enamel	K_2O	Na_2O	PbO	As_2O_3	B_2O_3	SiO_2
A	0.40	0.10	0.50	0.10	0.15	1.8
B	.40	.10	.50	.10	.15	1.9
C	.40	.10	.50	.10	.15	2.0
D	.40	.10	.50	.10	.15	2.1
E	.40	.10	.50	.10	.15	2.2

[1] *Loc. cit.*

BATCH WEIGHTS

Enamel	Pearl Ash	Soda Nitrate	Red Lead	Arsenious Oxide	Boric Acid	Flint
A	55.2	17.0	114	19.8	18.6	108
B	55.2	17.0	114	19.8	18.6	114
C	55.2	17.0	114	19.8	18.6	120
D	55.2	17.0	114	19.8	18.6	126
E	55.2	17.0	114	19.8	18.6	132

Every enamel in this series fractured, becoming worse with each increase silica. All enamels flowed well and had good luster and opacity.

Conclusions on Series I.—Increase of silica caused an increase in the tendency of the enamels to fracture but had no other bad effects except to raise the maturing temperature.

Series II

In Series II, Enamel "A" of Series I was chosen as the base enamel and the boric acid omitted. The RO, arsenic and silica were maintained constant and boric acid increased in steps of 0.1 equiv. as shown.

MOLECULAR FORMULA

Enamel	K_2O	Na_2O	PbO	As_2O_3	B_2O_3	SiO_2
A	0.40	0.10	0.50	0.10	0.0	1.8
B	.40	.10	.50	.10	.1	1.8
C	.40	.10	.50	.10	.2	1.8
D	.40	.10	.50	.10	.3	1.8
E	.40	.10	.50	.10	.4	1.8

BATCH WEIGHTS

Enamel	Pearl Ash	Soda Nitrate	Red Lead	Arsenious Oxide	Boric Acid	Flint
A	55.2	17.0	114	19.8	0	108
B	55.2	17.0	114	19.8	12.4	108
C	55.2	17.0	114	19.8	24.8	108
D	55.2	17.0	114	19.8	37.2	108
E	55.2	17.0	114	19.8	49.6	108

Every enamel in this series flows well.

A. Fractured when too thick—good opacity and luster.
B. Fractured—good luster and opacity.
C. Fractured—good luster and opacity.

D. Fracturing less pronounced—enamel comes mat—good opacity.

E. No fracturing—very mat and very opaque.

Conclusions on Series II.—Increase of boric acid above 0.2 equivalents caused the enamels to become mat. The mat finish of these enamels does not develop appreciably, if the enamel is drawn as soon as it is fused to glossy surface, but seems to develop if heated long enough for the enamel to flow out and fill an enclosure as in Cloisonne work. It has been suggested that this mat texture may be due to volatilization of some constituent from the enamel under prolonged heating, leaving a sort of vesicular structure which gives a mat surface. Whether this finish is due to volatilization or to crystallization, it develops only when boric acid and arsenic are both present in sufficient amount, and does not appear in these enamels if either of these constituents is omitted. Microscopic examination of these enamels would undoubtedly show the cause of this mat finish and prove of no little interest to the users of this type of enamel.

Fracturing in this series seemed to decrease with increase of B_2O_3, which is the converse of the results secured in Series I with increase of SiO_2. Since it is usual to assume that increase of either B_2O_3 or SiO_2 in a glass results in a decrease in its coefficient of expansion, the results of the two series seem rather contradictory. Since, however, variations in the thickness of coat applied has a decided influence on the development of defects in fit, it is the writer's opinion this series should be carefully checked by further investigation before definite conclusions are drawn.

Series III

In Series III, it was planned to use as the base enamel, a formula that would fracture in order to find what effect variation in the RO would have upon this defect, and Enamel I E was chosen as the base. Since it was desired to increase and decrease PbO in the same formula in steps of 0.1 equiv. it was necessary to make the base enamel the middle of the series. Enamel III D is, therefore, the base enamel of Series III, and as mentioned, is Enamel E of Series I, the As_2O_3 and SiO_2 being constant.

Enamel	Molecular Formula K_2O	Na_2O	PbO	As_2O_3	B_2O_3	SiO_2
A	0.10	0.10	0.80	0.10	0.15	2.2
B	.20	.10	.70	.10	.15	2.2
C	.30	.10	.60	.10	.15	2.2
D	.40	.10	.50	.10	.15	2.2
E	.50	.10	.40	.10	.15	2.2
F	.60	.10	.30	.10	.15	2.2
G	.70	.10	.20	.10	.15	2.2

Enamel	Batch Weights Pearl Ash	Soda Nitrate	Red Lead	Arsenious Oxide	Boric Acid	Flint
A	13.8	17.0	182.4	19.8	18.6	132
B	27.6	17.0	159.6	19.8	18.6	132
C	41.4	17.0	136.8	19.8	18.6	132
D	55.2	17.0	114.0	19.8	18.6	132
E	69.0	17.0	91.2	19.8	18.6	132
F	82.8	17.0	68.4	19.8	18.6	132
G	96.6	17.0	45.6	19.8	18.6	132

Results

A. Rather mat—does not flow well and will not mature under 950°C. No fracturing—very opaque—attacks copper vigorously.

B. Good luster and opacity—does not flow well—not much softer than A—fractures rather badly—attack of copper not so pronounced.

C. Good luster and opacity—flows well—does not attack copper appreciably—fractures badly.

D. See Enamel I E.

E. Nice smooth enamel—flows well—good luster and opacity—good fit.

F. Good luster—poor opacity—flows well—good fit—rather soluble in water.

G. Same as F but no opacity—matures to a clear glass—quite soluble in water.

Conclusions on Series III.—Increase of K_2O at expense of PbO—decreased fracturing and attack of copper made enamel flow and mature at a lower temperature—decreased opacity and improved luster. The fact that Enamel A did not fracture may be due to the fact that it seemed impossible to properly mature this enamel without its becoming so stained with copper taken up from the trial piece as to turn it an unsightly green. It was, therefore, probably not entirely fused, which might account for its irregular behavior

General Conclusions

The results of this investigation seem to indicate that with an arsenic content of 0.1 equivalent As_2O_3 in an enamel of this type applied by the dry method, the following relations hold ture.

1. Increase of silica with RO, arsenic and boric acid constant, increases tendency of enamels to fracture, increases refractoriness, does not affect opacity except by dilution and does not affect luster.

2. Increase of boric acid above 0.2 equivalents, with RO, arsenic and silica constant, causes enamels to become mat. Increase of boric acid decreases tendency toward fracturing, which is the converse of results obtained in Series I with increase of silica.

3. Increase of K_2O at expense of PbO with arsenic, boric acid and silica constant, causes enamels to flow better, mature at a lower temperature, increases solubility, decreases tendency to fracture, and those enamels containing more than six-tenths equivalents KNaO mature to a clear glass.

4. High lead enamels are very opaque but do not flow well and show an excessive attack of the copper.

From the data at hand, the writer feels justified in recommending the following limits in composition for enamels of this type.

MOLECULAR FORMULA LIMITS

$$\left.\begin{matrix} 0.3\text{–}0.6\ KNaO \\ .7\text{–}\ .4\ PbO \end{matrix}\right\} \left\{\begin{matrix} 1.3\text{–}1.8\ SiO_2 \\ 0\ \ \text{–}0.2\ B_2O_3 \\ 0.05\text{–}0.15\ As_2O_3 \end{matrix}\right.$$

As stated at the beginning of this paper, no claims for the completeness of this work are made. The data are presented in the hope that it may prove of value in this field of the enamel industry and stimulate sufficient interest in others to continue the work here begun.

The writer takes this occasion to express his appreciation of the kindly assistance of Mr. Staley and Mr. Danielson of the Bureau of Standards in checking the data given above and their advice as to its presentation.

CERAMIC LABORATORIES
COONLEY MANUFACTURING CO.
CICERO, ILLINOIS

NICKEL OXIDE IN GLAZES[1]

By J. D. Whitmer

ABSTRACT

Colors produced from NiO.—The literature on this subject published in the Transactions of the Society is briefly reviewed.

Effects of variations of RO in cone 6 glazes on colors from nickel oxide.—*Red* colors are produced when ZnO and BaO are used in certain proportions. *Blues* and *purples* of varied shades and hues are developed with varied combinations of ZnO, CaO and BaO. *Grays* are possible in presence of CaO and MgO.

The transactions of our Society contain a few references to the colors produced by nickel oxide in glazes. These references are scattered through a number of volumes. To gather up the data and present it together with any new developments which might be obtained is the purpose of this paper. Furthermore, it was desired to determine, if possible, the influence exerted by each RO oxide on colors produced by oxide of nickel.

The conditions outlined make necessary, therefore, some overlapping with work previously done. This repetition, however, serves a useful purpose in emphasizing and strengthening conclusions already drawn.

Geijsbeck[2] states that Le Chatielier and Chaupuy in Paris reported the following colors obtained from nickel oxide in oxidizing fire: violet, blue, green, yellow, red and brown. Many of these colors are familiar to most of us. Some no doubt are unusual. Browns and yellows are the usual colors in lead glazes and under ordinary conditions. Blues and greens, more or less familiar colors, were once attributed to traces of cobalt in with the oxide of nickel.

Pence, however, in his study,[3] "Colors Produced by Nickel Oxide in Ceramic Mixtures Containing Zinc," demonstrates that nickel oxide of the highest purity gives colors changing from

[1] Received March 10, 1921.

[2] *Trans. A. C. S.*, **6**, 195.

[3] *Trans. A. C. S.*, **14**, p. 144.

brown through purple, reddish purple to blue as ZnO replaces BaO and CaO, and further that the blues thus obtained can not be duplicated by the use of cobalt oxide.

Nothing more red than the reddish tone of purple obtained by Pence had ever come under my observation. Hence the possibility of producing a red color from NiO was quite alluring. In paper presented[1] last year it was demonstrated that gray colors are produced by NiO in the presence of MgO.

Experimental

Inasmuch as this work is a continuation and enlargement of that previously reported, the base glaze used was the same and much of the present investigation was based on the results obtained at that time. The work was so planned that as each RO oxide replaced another the effect on the color produced by NiO could be noted.

The following base glaze was used:

$$\left.\begin{matrix} 0.25\ K_2O \\ .45\ BaO \\ .30\ CaO \end{matrix}\right\} 0.35\ Al_2O_3 — 2.00\ SiO_2$$

The amount of NiO used was kept at 0.025 equivalent except in Series X; it was a straight addition to each glaze.

Series 1—ZnO *vs.* **BaO.**—This is a continuation of a series in the previous paper[2] in which ZnO replaces BaO. In the present instance the ZnO replaces BaO by 0.05 equivalent until the latter is eliminated from the formula.

Series 2—CaO *vs.* **K_2O.**—With no BaO in the RO, CaO replaces K_2O by 0.05 equivalent until the latter is eliminated from the formula. It will be noted here that the final 0.05 K_2O was replaced by 0.05 ZnO making the last glaze of the series have an RO of 0.5 ZnO, 0.5 CaO.

Series 3—ZnO *vs.* **CaO.**—We start this series with the original RO formula, 0.25 K_2O, 0.30 CaO, 0.45 BaO. ZnO replaces CaO by 0.05 equivalent until CaO is eliminated from the formula. We may compare this with Series 1 wherein ZnO replaces BaO.

[1] *J. Am. Ceram. Soc.*, **1920**, 663.

[2] *Loc. cit.*

Series 4—ZnO *vs.* K_2O.—Wishing to parallel the high CaO-ZnO glaze of Series 2, the K_2O in glaze 6 of Series 3 was replaced by ZnO in increments of 0.05 equivalent until the content of 0.5 ZnO is reached. The remaining 0.05 K_2O is then replaced by 0.05 BaO and we have glaze 5 with an RO content of 0.5 BaO, 0.5 ZnO.

In order to determine the different effects produced when MgO replaced each of the other RO oxides, the four following series were constructed:

Series 5.—With an RO consisting of 0.15 K_2O, 0.40 ZnO, 0.45 BaO as in glaze 2, series 4, MgO replaces BaO by 0.05 equivalents up to and including 0.20 MgO. ZnO and K_2O do not change.

Series 6.—With the same RO as in Series 5, MgO replaces ZnO in like manner, the BaO and K_2O remaining unchanged.

Series 7.—Starting with an RO consisting of 0.15 K_2O, 0.45 CaO, 0.40 ZnO, MgO replaces CaO by 0.05 equivalents until a content of 0.20 MgO is reached. ZnO and K_2O remain unchanged.

Series 8.—Using the same RO as in series 7, MgO replaces ZnO in like manner, the K_2O and CaO remaining constant.

When the results of these eight series were noted and it was found that a red color was obtained in glaze 2, series 4, the two following series were added to indicate what effect, if any, variations in the Al_2O_3 and NiO content might have on the red color.

Series 9.—Starting with glaze 2, series 4, Al_2O_3 was reduced by 0.05 equivalents to 0.10 equivalent, keeping the oxygen ratio constant at 1:2.

Series 10.—With the same glaze, the nickel oxide was varied from 0.025 to 0.10 equivalent.

Materials.—Formulae and batch weights of all the glazes are found in table 1. The materials used in this investigation were taken from regular factory stock and include the following: Eureka Feldspar, English Cliffstone Whiting, Red Seal Oxide of Zinc, Oxide of Nickel, Granville Flint, Cornwall Stone, Precipitated Barium Carbonate, Calcined Magnesite, Calcined N. C. Kaolin.

TABLE 1

Series 1

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

Glaze No.	Formulae				Batch Weights							
	K_2O	CaO	BaO	ZnO	Feldspar	Stone	Whiting	Barium Carb.	Oxide Zinc	Calc. Clay	Flint	Nickel Oxide
1	0.25	0.30	0.20	0.25	83.4	84.3	30.0	39.4	20.25	14.43	...	1.87
2	.25	.30	.15	.30	83.4	84.3	30.0	29.55	24.30	14.43	...	1.87
3	.25	.30	.10	.35	83.4	84.3	30.0	19.70	28.35	14.43	...	1.87
4	.25	.30	.05	.40	83.4	84.3	30.0	9.85	32.40	14.43	...	1.87
5	.25	.30	.00	.45	83.4	84.3	30.0	...	36.45	14.43	...	1.87

Series 2

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

1	0.20	0.35	....	0.45	83.4	42.15	35.0	...	36.45	29.41	19.74	1.87
2	.15	.40	....	.45	55.6	42.15	40.0	...	36.45	40.51	31.74	1.87
3	.10	.45	....	.45	55.6	...	45.0	...	36.45	55.50	54.00	1.87
4	.05	.50	....	.45	27.8	...	50.0	...	36.45	66.60	66.00	1.87
5	.00	.50	....	.50	...	...	50.0	...	40.50	77.70	78.00	1.87

Series 3

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

1	0.25	0.25	0.45	0.05	83.4	84.3	25.0	88.65	4.05	14.43	...	1.87
2	.25	.20	.45	.10	83.4	84.3	20.0	88.65	8.10	14.43	...	1.87
3	.25	.15	.45	.15	83.4	84.3	15.0	88.65	12.15	14.43	...	1.87
4	.25	.10	.45	.20	83.4	84.3	10.0	88.65	16.20	14.43	...	1.87
5	.25	.05	.45	.25	83.4	84.3	5.0	88.65	20.25	14.43	...	1.87
6	.25	.00	.45	.30	83.4	84.3	...	88.65	24.30	14.43	...	1.87

Series 4

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

1	0.20	....	0.45	0.35	83.40	42.15	...	88.65	28.35	29.41	19.74	1.87
2	.15	....	.45	.40	55.60	42.15	...	88.65	32.40	40.51	31.74	1.87
3	.10	....	.45	.45	55.60	...	...	88.65	36.45	55.50	54.00	1.87
4	.05	....	.45	.50	27.80	...	...	88.65	40.50	66.60	66.00	1.87
5	.00	....	.50	.50	...	...	...	98.50	40.50	77.70	78.00	1.87

Series 5

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

Glaze No.	Formulae				Batch Weights							
	K_2O	BaO	ZnO	MgO	Feldspar	Stone	Barium Carb.	Oxide Zinc	Calc. Magnesite	Calc. Clay	Flint	Nickel Oxide
1	0.15	0.45	0.40	0.00	55.60	42.15	88.65	32.40	...	40.51	31.74	1.87
2	.15	.40	.40	.05	55.60	42.15	78.80	32.40	2.015	40.51	31.74	1.87
3	.15	.35	.40	.10	55.60	42.15	68.95	32.40	4.030	40.51	31.74	1.87
4	.15	.30	.40	.15	55.60	42.15	59.10	32.40	6.045	40.51	31.74	1.87
5	.15	.25	.40	.20	55.60	42.15	49.25	32.40	8.060	40.51	31.74	1.87

Series 6

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

1	0.15	0.45	0.35	0.05	55.60	42.15	88.65	28.35	2.015	40.51	31.74	1.87
2	.15	.45	.30	.10	55.60	42.15	88.65	24.30	4.030	40.51	31.74	1.87
3	.15	.45	.25	.15	55.60	42.15	88.65	20.25	6.045	40.51	31.74	1.87
4	.15	.45	.20	.20	55.60	42.15	88.65	16.20	8.060	40.51	31.74	1.87

Series 7

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

		CaO					Whiting					
1	0.15	0 40	0.45	0.00	55.6	42.15	40.0	36.45	...	40.51	31.74	1.87
2	.15	.35	.45	.05	55.6	42.15	35.0	36.45	2.015	40.51	31.74	1.87
3	.15	.30	.45	.10	55.6	42.15	30.0	36.45	4.030	40.51	31.74	1.87
4	:15	.25	.45	.15	55.6	42.15	25.0	36.45	6.045	40.51	31.74	1.87
5	.15	.20	.45	.20	55.6	42.15	20.0	36.45	8.060	40.51	31.74	1.87

Series 8

Common to all glazes: 0.35 Al_2O_3; 2.00 SiO_2; 0.025 NiO

		CaO					Whiting					
1	0.15	0.40	0.40	0.05	55.6	42.15	40.0	32.40	2.015	40.51	31.74	1.87
2	.15	.40	.35	.10	55.6	42.15	40.0	28.35	4.030	40.51	31.74	1.87
3	.15	.40	.30	.15	55.6	42.15	40.0	24.30	6.045	40.51	31.74	1.87
4	.15	.40	.25	.20	55.6	42.15	40.0	20.25	8.06	40.51	31.74	1.87

Series 9

Common to all glazes: 0.45 BaO; 0.025 NiO

	Formulae				Batch Weights						
Glaze No.	K_2O	ZnO	Al_2O_3	SiO_2	Feld-spar	Stone	Barium Carb.	Oxide Zinc	Calc. Clay	Flint	Nickel Oxide
1	0.15	0.40	0.35	2.00	55.6	42.15	88.65	32.40	40.51	31.74	1.87
2	.15	.40	.30	1.90	55.6	42.15	88.65	32.40	29.41	31.74	1.87
3	.15	.40	.25	1.75	55.6	42.15	88.65	32.40	18.32	28.74	1.87
4	.15	.40	.20	1.60	55.6	42.15	88.65	32.40	7.22	25.74	1.87
5	.15	.40	.15	1.45	83.4	...	88.65	32.40	...	33.00	1.87
6	.10	.45	.10	1.30	55.6	...	88.65	36.45	...	42.00	1.87

Series 10

Common to all glazes: 0.45 BaO; 2.00 SiO_2

	Formulae				Batch Weights						
Glaze No.	K_2O	ZnO	Al_2O_3	NiO	Feld-spar	Stone	Barium Carb.	Oxide Zinc	Calc. Clay	Flint	Nickel Oxide
1	0.15	0.40	0.35	0.025	55.6	42.15	88.65	32.4	40.51	31.74	1.87
2	.15	.40	.35	.050	55.6	42.15	88.65	32.4	40.51	31.74	3.74
3	.15	.40	.35	.075	55.6	42.15	88.65	32.4	40.51	31.74	5.61
4	.15	.40	.35	.100	55.6	42.15	88.65	32.4	40.51	31.74	7.48

The glazes were weighed up separately, ground in small trial mills and applied, by dipping, to thin porous wall tile bisque ($1^1/_2'' \times 1^1/_2'' \times 0^1/_8''$).

All glazes except those of series 9 and 10 were fired at the same time in a commercial down-draft kiln. The fuel used was natural gas. Cones placed in each sagger of glazed tile indicated a temperature corresponding to cone 6.

The majority of the glazes were matured at this temperature although some of those high in MgO were somewhat immature. The glazes of series 9 and 10 were fired at another time but the cones indicated a heat treatment very similar to that of the first burn.

Results

Series 1.—Glaze 1, reddish purple; glaze 2, more blue than glaze 1; glaze 3, mingled blue and tan, the blue apparently consisting of crystals on a tan background; glaze 4, goes bright, blue where thickest, yellowish color on edges of tile where thinnest; glaze 5, greenish matt, tending to blue crystalline where thickest.

The odd behavior of glaze 4 which went bright was attributed to a mistake in weighing the glaze, but a new batch, carefully checked, was made up and upon firing gave very similar results. Evidently some peculiar action, similar to the formation of a eutectic, occurs with 0.05 BaO.

These results indicate that an increase of ZnO at the expense of BaO gives colors tending toward blues and greens and away from purple tones. This contradicts Minton's statement[1] in his discussion of my paper last year that "the effect of BaO produces blue green with NiO" and confirms my previous observations.

Series 2.—Glaze 1, crystalline blue, similar to glaze 5, series 1, from which it differs only by 0.05 CaO replacing 0.05 K_2O. The crystals are small but the effect is very pleasing; glaze 2, purplish blue of slightly mottled nature; glaze 3, similar to glaze 2; glazes 4 and 5, more of grey blue color. The increase of CaO at expense of the K_2O seems to intensify the resulting blue color.

[1] *J. Am. Ceram. Soc.*, **1920**, 669.

High whiting and high zinc together gives light greyish blues. The surface of glaze 5 which contains only CaO and ZnO in the RO is of an unpleasant greasy nature.

Series 3.—Glaze 1, brown; glaze 2, purplish blue; glaze 3, purplish blue; glaze 4, purple; glaze 5, about like glaze 4; glaze 6, reddish purple.

The results of this series confirm Pence's statement that purples and blues are developed as ZnO increases at the expense of BaO and CaO. If we compare the results of this series with the results obtained in series 1 last year wherein ZnO was used to replace BaO, we see that BaO and CaO produce much the same colors when used in connection with ZnO.

Series 4.—Glazes 1 and 2, these glazes develop decided reds which have a more or less purplish tone; glaze 3, light blue, similar to glaze 4, series 2; glaze 4, similar to glaze 3; glaze 5, more reddish than glazes 3 and 4.

In this series, with high ZnO and BaO, the reddish tone frequently observed has developed into a red of a somewhat purplish tone. This red develops where the glaze is dipped rather heavy and seems to be a segregation on the surface of the blue. Where the glaze is dipped light, the blue color predominates with only here and there a fleck of red on the surface. This red color seems to be developed within the following narrow limits of RO composition:

0.15	0.20 K_2O
.35	.40 ZnO
.45	.40 BaO

Later experiments tend to confirm this action and indicate that a variation of only about 0.05 equivalent in any one of these three oxides is permissible.

Series 5.—Glaze 1, red; glaze 2, blue; glaze 3, blue; glaze 4, lighter blue; glaze 5, lighter blue, nearer to turquoise.

The replacement of BaO with MgO in presence of ZnO gives blues, but lightens the tone. No purple blues are noticeable. The glazes are hardened somewhat as the MgO increases.

Series 6.—Glaze 1, blue; glaze 2, light grey blue; glaze 3, faded lilac; glaze 4, more grey than glaze 3.

The MgO replacing ZnO in presence of BaO hardens the glaze more than in the previous series. Furthermore, greater changes in color occur. This is equivalent to saying that ZnO has a more powerful effect on the color produced by NiO than has CaO and BaO.

Series 7.—Glaze 1, medium dark blue; glaze 2, bright glaze, yellow brown with blue segregations (Compare glaze 4, series 1); glaze 3, light green semi-matt; glaze 4, lighter in color than glaze 3, semi-matt; glaze 5, still lighter than glaze 4.

In glaze 2 this series, with a content of 0.05 MgO, we observe the same phenomenon as in glaze 4, series 1, which contains 0.05 BaO. The glazes in this series are hardened when MgO replaces CaO and the colors are lightened and tend toward grey greens.

Series 8.—Glaze 1, light blue; glaze 2, mingled grey and blue; glaze 3, good grey; glaze 4, grey, slightly browner than glaze 3.

In this series, wherein MgO replaces ZnO in presence of CaO, nice greys are developed. Last year it was shown that greys were developed when MgO replaced BaO with no ZnO in the formula. This leads to the conclusion that greys are not developed when the ZnO is present in too large quantities and the tendency of ZnO is to produce greys of bluish tones.

Series 9.—All glazes of this series are reds of the same purplish tone as glazes 1 and 2, series 4. The reduction of Al_2O_3 does not destroy the red color. It does, however, soften the glaze and produces better surfaces.

Series 10.—The red color changes from purplish to brownish as the NiO is increased.

Discussion of Results

A study of these results brings out some interesting facts. In the first place, a very interesting red color has been produced using NiO as the coloring agent. This color seems to be confined to a very narrow range of glaze composition so far as the RO is concerned. A content of not less than 0.35 BaO and 0.35 ZnO seems necessary, but both must not be this low at the same time.

This red color seems to be a crystalline segregation on the surface of a blue color, the blue always predominating when the glaze is dipped light. Within the limits studied the Al_2O_3 content may vary at will. The content of NiO influences the shades of red produced.

In the second place, more data on the development of grey colors is noted. It appears that CaO is necessary to the formula in producing greys; that the ZnO should not exceed 0.30 equivalent; that the MgO should approximate 0.15 equivalent; that BaO is not necessary in the formula, but that its presence is not detrimental. BaO may replace a part of the CaO as was shown in the paper of last year.

Conclusions

We conclude, therefore, that the following statements are justified as a result of this study:

(1) The dominant tendency of ZnO is to produce blue colors with NiO, as already reported by Pence.

(2) ZnO is not necessary in the production of greys with NiO but may be present if it does not exceed 0.30 equivalent.

(3) BaO with CaO and K_2O gives browns, with ZnO, purples, reddish purples and reds when the proper proportions are used.

(4) BaO is not necessary to produce greys but may be present in the formula partly replacing CaO.

(5) CaO with ZnO produces blues and must be present with MgO to produce greys.

(6) MgO tends to produce greyish tints when used with other oxides. To produce neutral greys it should be used with CaO or a combination of CaO and BaO. Bluish tones of grey are obtained when ZnO is present.

(7) The coloring influence of K_2O is slight but its presence promotes maturity and good surfaces.

AMERICAN ENCAUSTIC TILING COMPANY
ZANESVILLE, OHIO

NOTE ON THE EFFECTS OF FIRING TEMPERATURES ON THE STRENGTH OF FIRE-CLAY AND STONEWARE BODIES[1]

By H. G. Schurecht

ABSTRACT

The cross breaking strengths, porosities and shrinkages of fire-clay and stoneware bodies were determined after firing to different temperatures. It was found that with one exception, *maximum strength was developed by firing to cone 8, even when porosity and shrinkage data showed the bodies to be over or underfired at this temperature.* The cause of weakening above cone 8 may be due to the formation of sillimanite. Bodies which develop maximum shrinkage and minimum porosity at cone 8 have a greater ratio of fired strength to dry strength when fired to cone 8, than those which are under or overfired at cone 8.

Considerable work has been done on the physical properties of clays fired at different temperatures as evidenced by the fact that a very large per cent of the Society's publications falls under this general head. Much still remains to be done and as time advances, more data are being added to our present knowledge. Since the durability of certain clay wares is closely related to their physical properties such as modulus of rupture, compression, tensile strength and torsion strengths, resistance to impact, modulus of elasticity, etc., a closer study of these properties and of the factors governing them is important.

In studying stoneware and fire-clays, it was observed that the firing temperatures were in general more effective in producing maximum cross-breaking strength than was the degree of vitrification. For most clays of the fire-clay type, maximum strength was developed by firing to cone 8, regardless of the degree of vitrification.

The porosity and shrinkage data showed that many clays and mixtures developed maximum shrinkage and minimum porosity at temperatures below cone 8, but did not develop maximum

[1] Received March 10, 1921. Published by permission of the Director, U. S. Bureau of Mines.

Figure 1

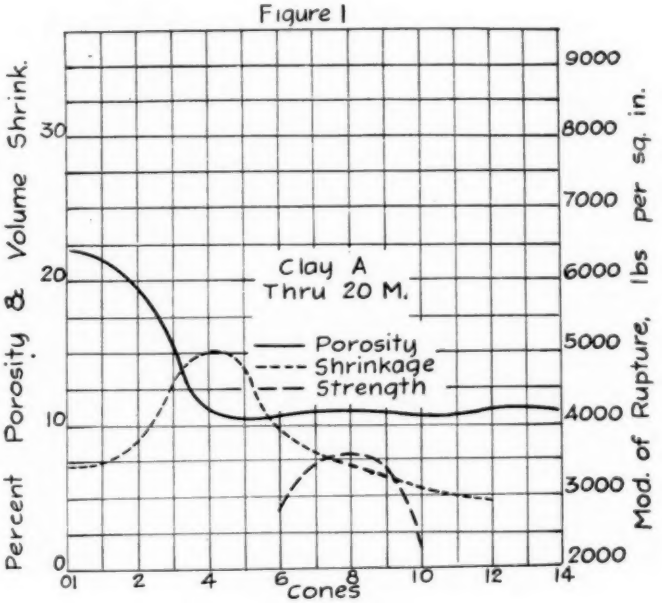


Figure 2

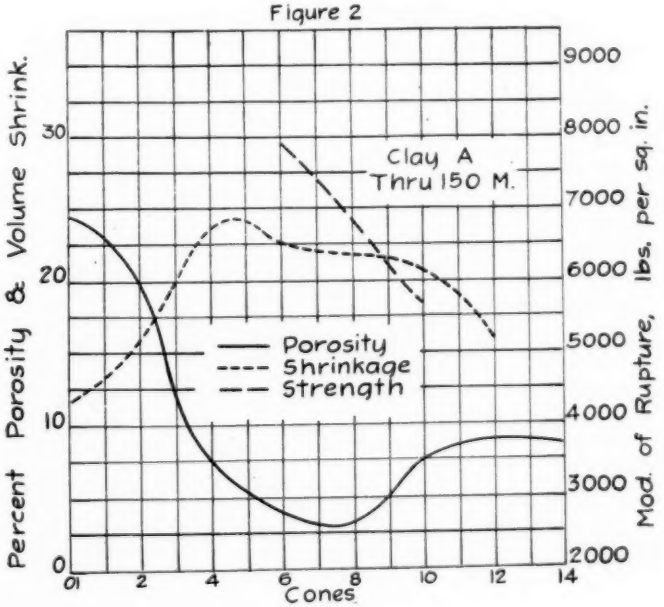


Figure 3.

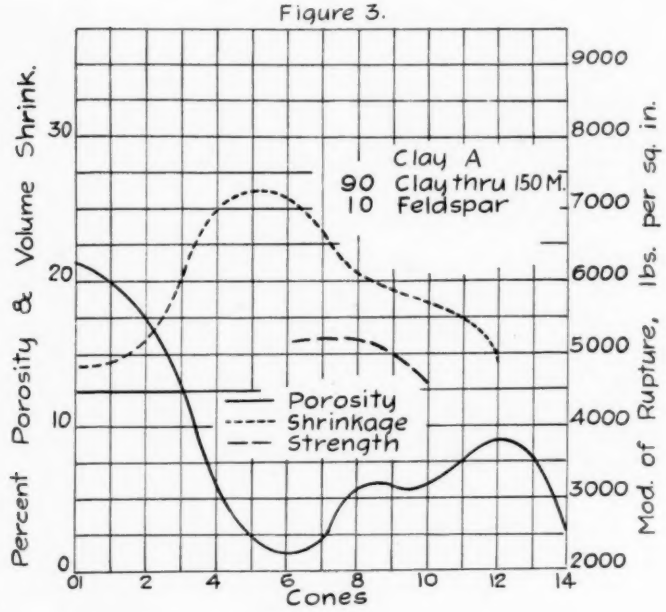


Figure 4.

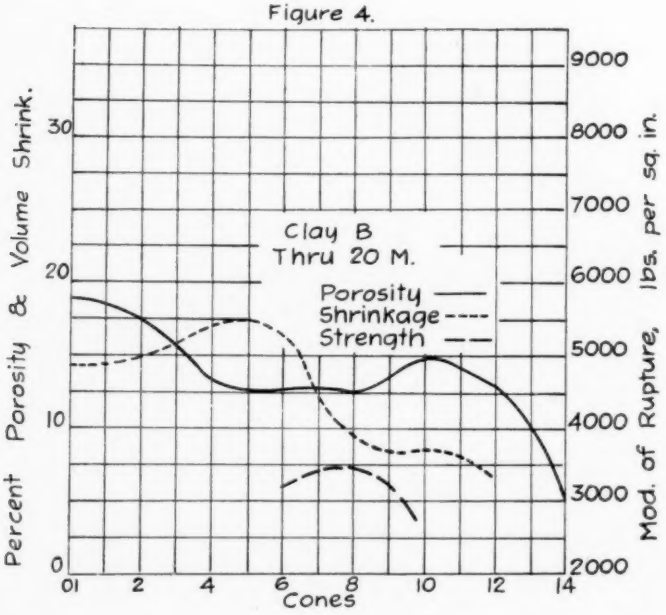


Figure 5

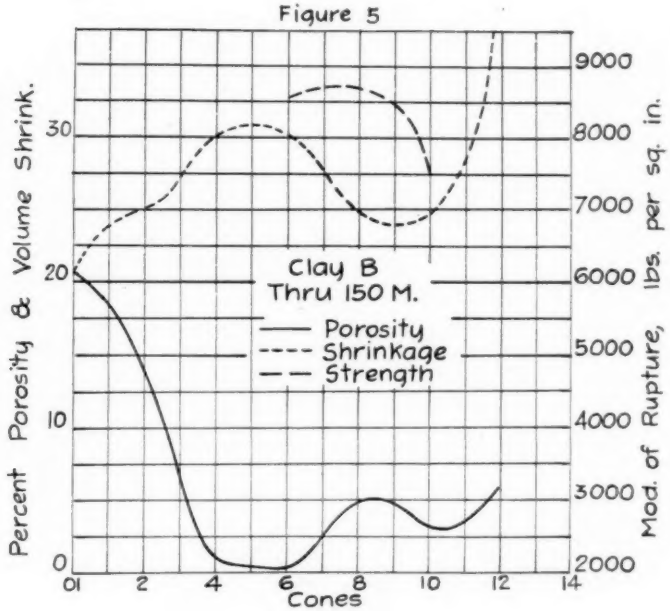


Figure 6.

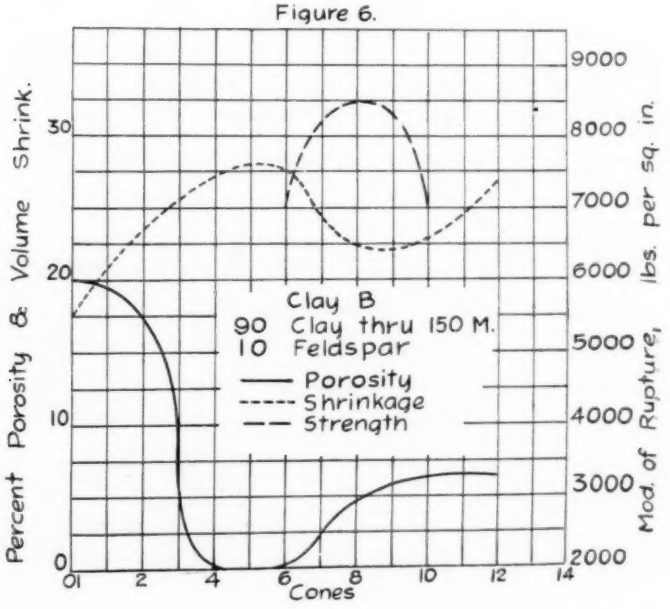


Figure 7

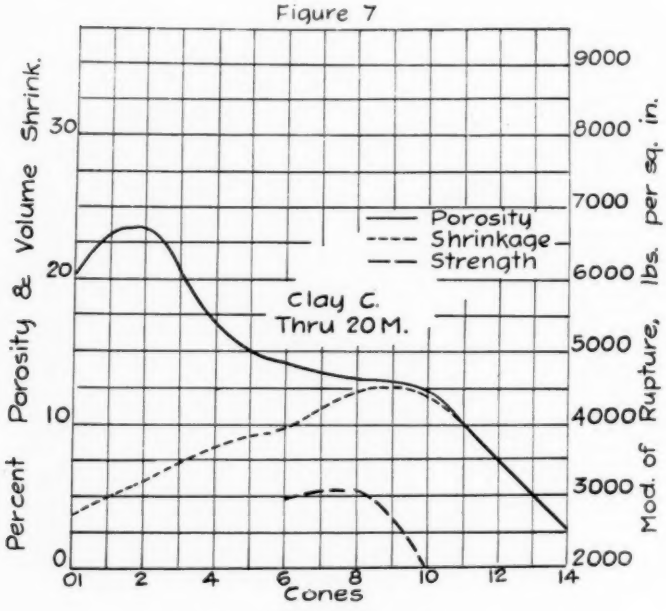


Figure 8

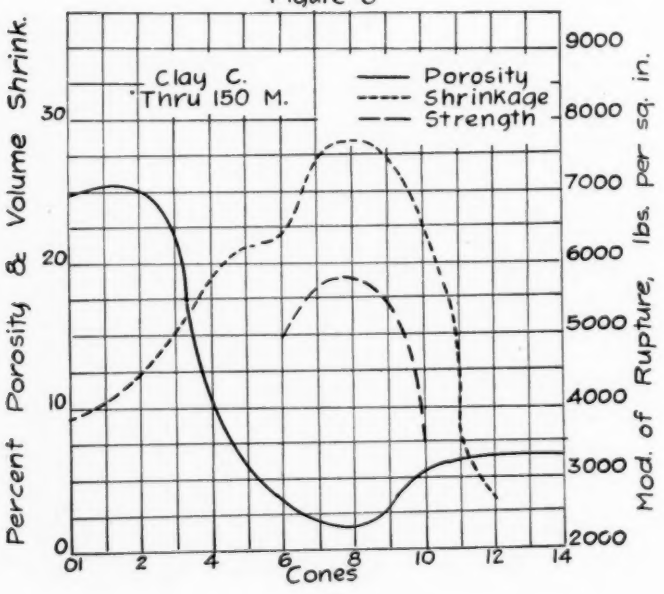


Figure 9.

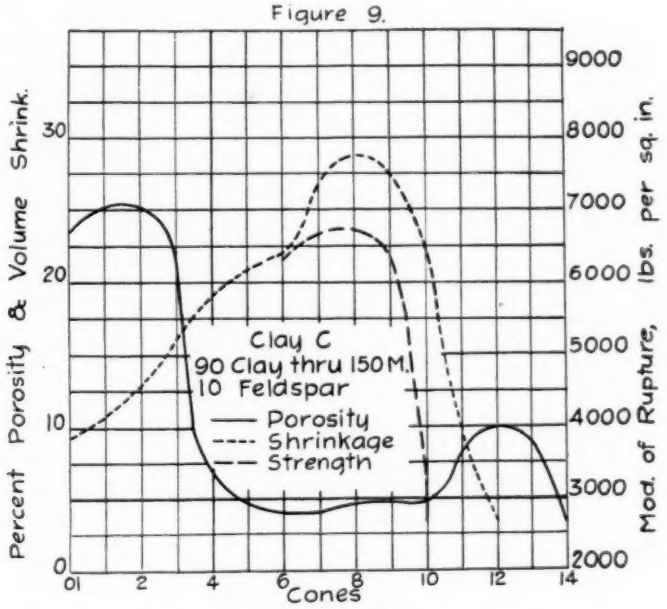


Figure 10

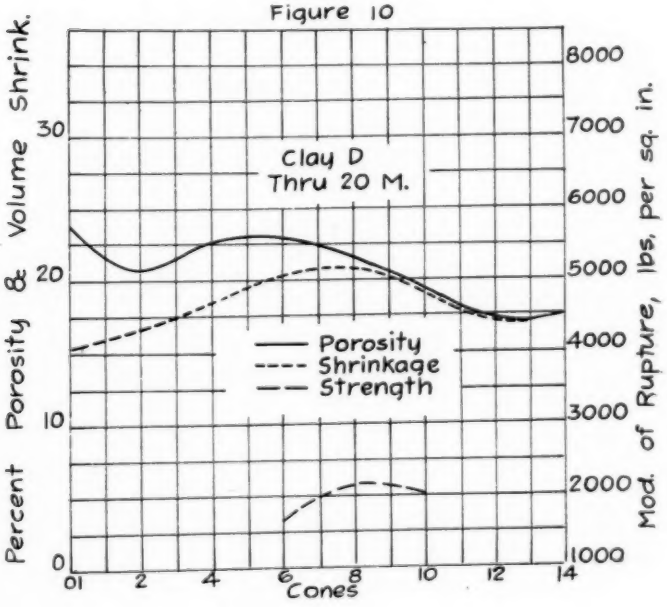


Figure 11

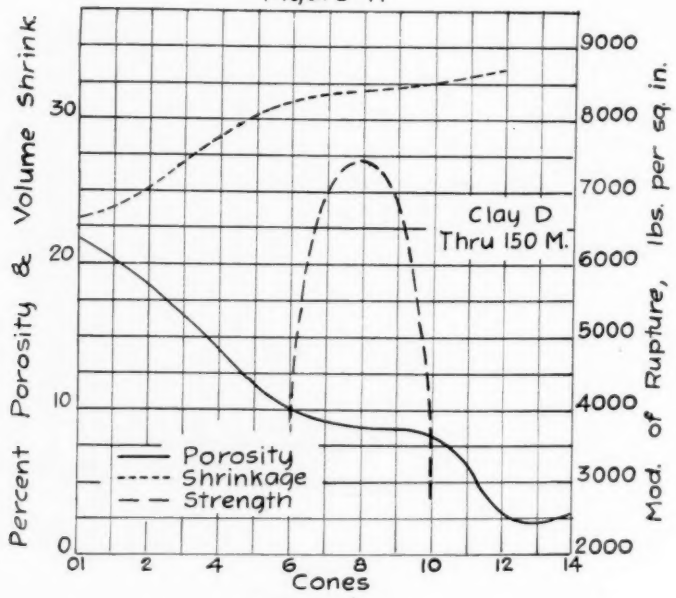
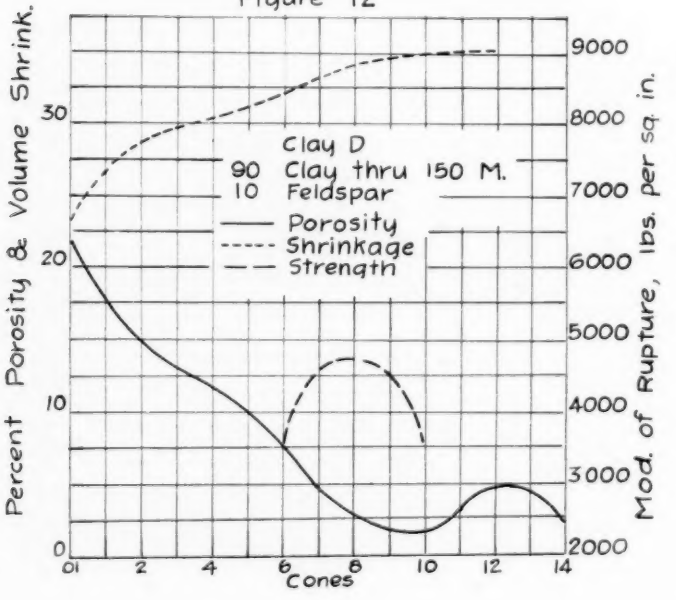


Figure 12



strength until they were fired at cone 8, although they had commenced to swell due to overburning at that temperature. The results observed in clays of this type are shown in figures 1, 3, 4, 5 and 6. In figure 2 is shown a similar clay in which the strength decreased when fired to cones 8 and 10, as would be expected. This, however, is an exception rather than the rule.

TABLE 1—MISCELLANEOUS PROPERTIES OF CLAYS AND MIXTURES TESTED

	% porosity at cone 8	Mod. of rupture, lbs. per sq. in. dried at 100 °C.	Modulus of rupture, lbs. per sq. in. fired at			Ratio of mod. of rupture after firing at cone 8 to that when dried at 100°C.	Clays soften at cone No.
			cone 6	cone 8	cone 10		
Clay A through 20 M.	10.93	384.3	2788.7	3568.7	2260.0	9.30	26—
Clay A through 150 M	13.25	532.	7904.3	6847.5	5690.0	12.85	...
Clay A through 150 M —90, Feldspar —10.	5.69	...	5128.6	5191.6	4584.0	...	...
Clay B through 20 M.	12.48	218.6	3190.0	3416.2	2665.0	15.7	26+
Clay B through 150 M	4.97	...	8556.0	8680.0	7504.8	27.2	...
Clay B through 150 M —90, Feldspar —10.	4.77	...	7010.0	8482.0	7050.0	...	...
Clay C through 20 M	13.24	194.2	2911.2	3063.0	1909.0	15.8	28
Clay C through 150 M	1.03	191.0	4932.5	5815.0	3368.0	32.0	..
Clay C through 150 M —90, Feldspar —10.	4.44	...	6275.0	6727.0	2675.0	...	..
Clay D through 20 M	21.65	93.8	1649.4	2129.3	2041.0	23.0	32+
Clay D through 150 M	8.70	270.0	3655.0	7411.0	2716.0	27.4	..
Clay D through 150 M —90, Feldspar —10.	2.95	...	3585.0	4710.0	3567.0	...	..

Clay A—Lower Kittaning clay, Toronto, Jefferson County, Ohio.
Clay B—Lower Kittaning clay, Roseville, Muskingum County, Ohio.
Clay C—Lower Kittaning clay, New Brighton, Beaver County, Penna.
Clay D—Semiflint clay, Scioto Furnace, Scioto County, Ohio.

Other clays and mixtures developed maximum shrinkage, minimum porosity, and maximum strength at cone 8. Clays of this type develop more strength than those which are over or underfired at cone 8, although the latter show their maximum strength after firing to cone 8. Clay C, through 150 mesh, which is of the former type (see Fig. 8 and table 1), developed, by firing to cone 8, a strength 32 times that possessed in the raw state. This is a greater ratio than obtained with clays and

mixtures which over or underburn at cone 8. Clays developing maximum shrinkage and minimum porosity at temperatures higher than cone 8, but still having maximum strength at cone 8, are shown in figures 7, 10, 11 and 12. The tendency of these bodies to weaken when fired above cone 8 may be due to the formation of sillimanite which begins to develop about the temperature.

It is therefore evident, that *maximum cross-breaking strength is developed by selecting a body which has maximum shrinkage and minimum porosity when fired at cone 8.* The observations so far have been made on fire-clays and bodies of the fire-clay type. Whether the results obtained on these clays and mixtures are in accord with those of porcelain and whiteware bodies will be determined later.

THE WATER SMOKING OF CLAYS[1]

By R. F. Geller

ABSTRACT

Experimental Method.—The water smoking behaviors of two plastic brick clays, one shale and one fire-clay were studied by heating 4-in. cubes at different rates, two thermo-elements being buried in the brick and two others placed against the exterior surface.

Results of Conclusions.—To save time in water smoking, the ware should be previously dried not far from 100 °C, good circulation should be provided in the kiln and the temp. of the interior of the product should not lag appreciably behind that of the kiln. It should be possible to water smoke heavy clay products in 15 hours with heating rate of 20 °C per hour.

Introduction

The introduction of the tunnel kiln and the general necessity of cutting down the time consumed in burning make it desirable to study the water-smoking process in greater detail than has been done in previous work and to establish the minimum time required for the expulsion of the hygroscopic water. This involves also the study of the thermal changes taking place in clay and the establishing of the minimum temperature necessary to drive off this last portion of the mechanically held water. The work, in brief, consisted in following the temperature lag due to the presence of the residual water both with reference to the magnitude of the lag and its connection with any critical temperatures.

The materials studied were two plastic brick clays from the District of Columbia Workhouse, which are of an exceedingly tough structure and retain water very tenaciously; a shale from Milton, Pa., and one from the District Workhouse; and one fire-clay from Lester, Arkansas.

The plastic clays were chosen for this purpose oweing to their exceedingly well developed plastic structure. Each sample was ground to pass the 20-mesh sieve, pugged thoroughly to a stiff plastic consistency and pressed by hand in molds to form

[1] Received Feb. 14, 1921; published by permission of the Director Bureau of Standards.

four-inch cubes. Some of the specimens were previously dried to constant weight at 50°C before being subjected to the water-smoking treatment. Others were air-dried in the laboratory from one to five days at atmospheric temperature.

The water-smoking process itself was conducted in an electrically heated oven, the inside dimensions of which were 8 × 8 × 12 inches. In each run the test piece was placed in the center of the furnace thus permitting free circulation of air on all faces of the cube. The furnace temperatures were read by means of copper-constantan thermo couples in contact with the upper and lower surfaces of the cube. A gentle current of air was provided for the removal of the steam. The temperatures within the cube were obtained from two thermo couples embedded within the piece at depths of one and two inches, respectively. All the temperature readings were recorded by means of a multiple point potentiometer. The maximum temperature to which the specimens were carried was 300°C. The duration of the water-smoking treatment was varied from three to eighteen hours.

Experimental

The results obtained are illustrated in the diagrams of figures Nos. 1 to 16, and these curves will be discussed in order in the following paragraphs:

Figure 1.—This specimen made from the plastic brick clay, as well as those immediately following, was dried to constant weight at 50°C previous to the water-smoking treatment. The furnace was brought to 300°C in three hours. It will be observed that beginning with room temperature the lag between the furnace temperature and that of the cube increases steadily, indicating increased heat absorption by the clay. This condition continues after the furnace has reached the maximum temperature. It is interesting to note that there was practically no lag between the points one inch distant within the cube, showing that the conductivity of the clay is very much greater than we should expect since even with this fast rate of heating there was such complete equalization. It is evident, however, that the rate of heating was entirely too fast.

Figure 2.—In this experiment we have the same clay, the

plastic material from the District Workhouse, and it will be observed that although the time of drying has been doubled the area of heat absorption does not tend to diminish appreciably, indicating that considerable heat work is being done in removing

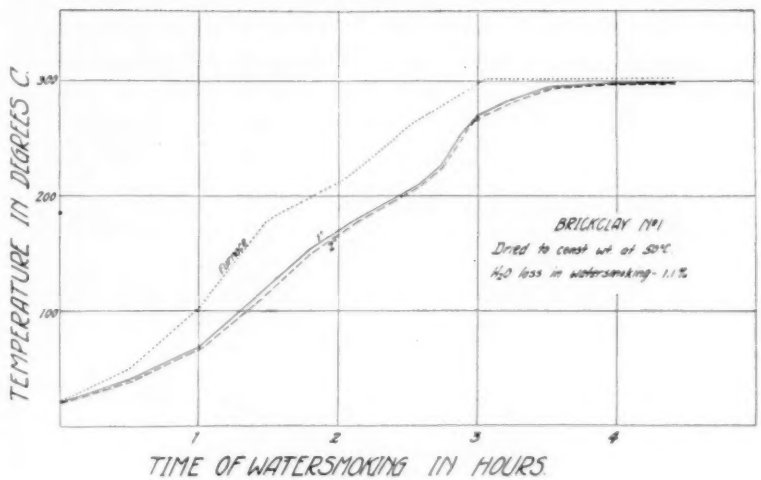


FIG. 1

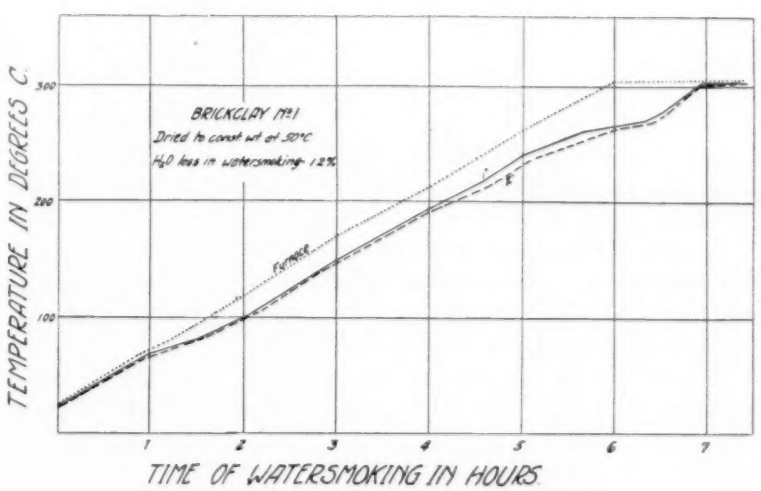


FIG. 2

the hygroscopic water and that the rate of heating is still so fast that there is a decided lag between the furnace and clay temperatures.

Figure 3.—Here again we have the same clay previously dried to 50°C but heated to 300°C in 12 hours. It will be observed that the temperature lag is nearly constant throughout the run and that the temperature of the cube coincides with the furnace temperature only after one hour's heating at 300°C. The inflections of the cube temperatures shown in the curves of

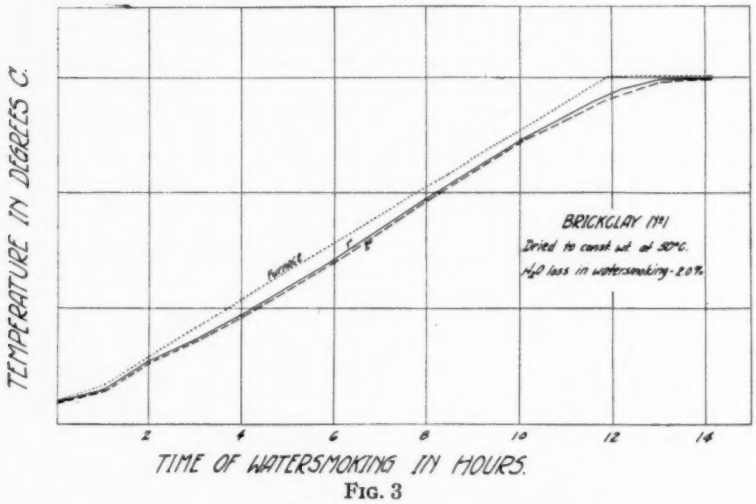


FIG. 3

figures 1 and 2 at approximately 80°C and 280°C have been smoothed out although there is some indication of the higher lag point.

Figure 4.—The material represented by this diagram is a soft shale which shows an even greater heat absorption than the clay previously discussed but gives indications of reaching thermal equilibrium somewhat more rapidly.

Figure 5.—This diagram again represents the plastic brick clay discussed above but with a water-smoking run of 15 hours. This rate of heating thus has removed the lag so apparent in the previous diagram, inasmuch as the temperatures of the clay followed the furnace temperature very closely, thus indicating

that the heat requirements of the clay at each particular point are met by the furnace with sufficient promptness. It is evident that such a condition of gradual and constant vaporization tends to carry through the process without undue strains due to the

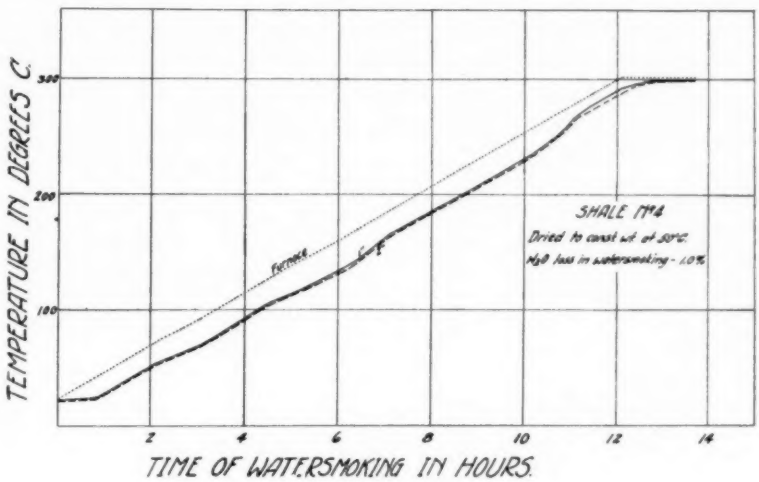


FIG. 4

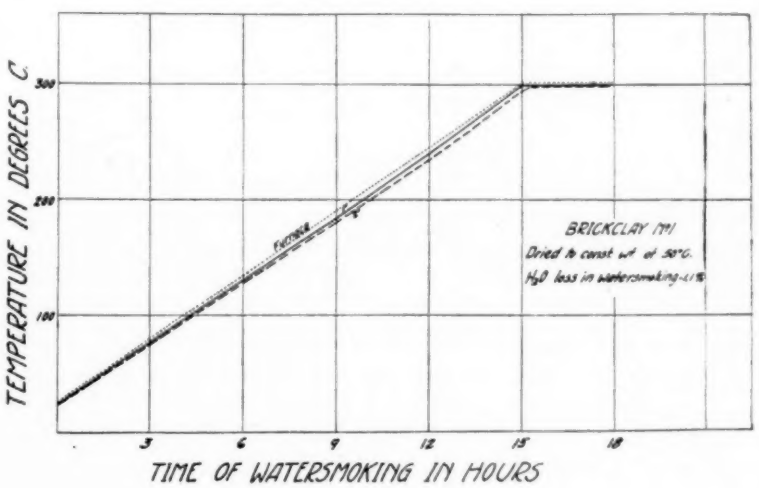


FIG. 5

temperature differences between the surface and the center of the cube. Such a condition is therefore very desirable in actual burning operations.

Figure 6.—This diagram represents another of the very plastic brick clays, studied with a high content of hygroscopic water,

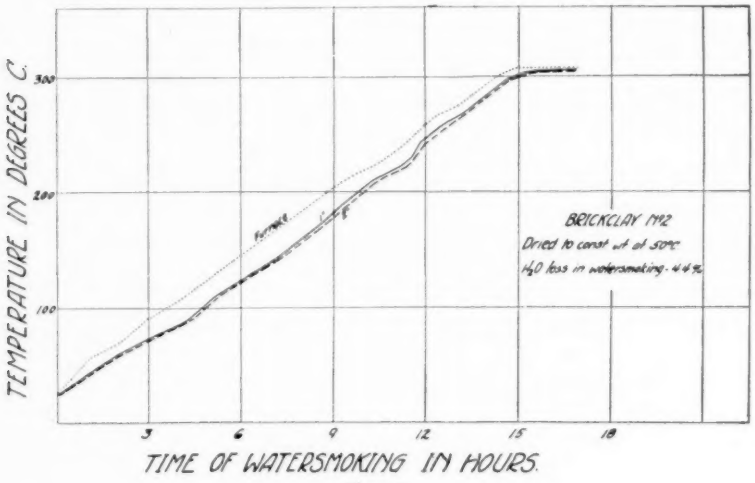


FIG. 6

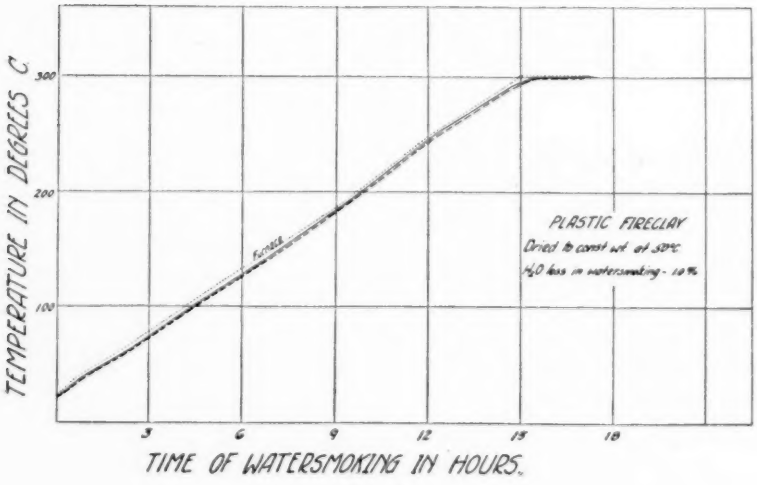


FIG. 7

approximately 4.4 per cent. Here again the duration of the run was 15 hours, but the high water content has been found to cause a distinct lag which persists up to the maximum temperature. The increasing lag between the two cube temperatures towards the end of the run would indicate decreased heat conductivity brought about by the drying out of the clay.

Figure 7.—These curves represent the heating up of the plastic silicious fire-clay containing one per cent of hygroscopic water. It is observed that there is only a slight lag between the tempera-

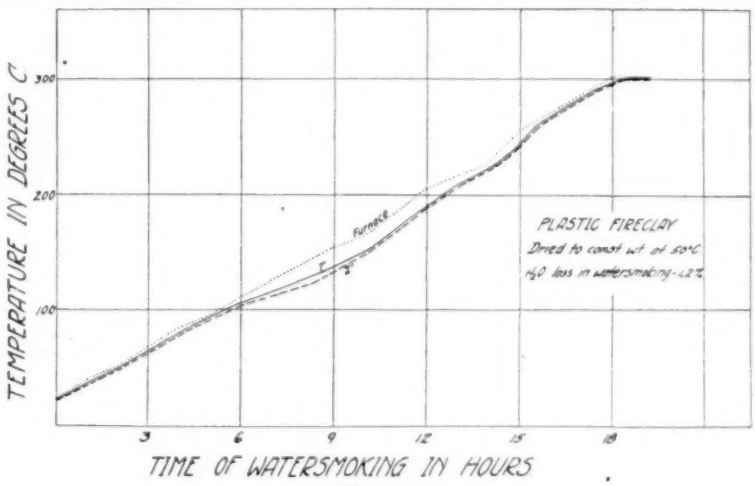


FIG. 8

tures of the furnace and of the clay specimen, indicating that this rate of heating provided all the thermal energy required for water smoking without any appreciable temperature difference within the cube. The heat treatment, therefore, is entirely normal and satisfactory.

Figure 8.—Representing the same fire-clay but with a slightly higher content of hygroscopic water, this diagram is of interest inasmuch as it indicates the temperature limits between 100 and 250°C.

It was then decided to determine the temperature range between which the process of water smoking takes place and at the same time fix the critical temperatures involved with greater cer-

tainty. It was evident from the previous work that clays previously dried to 50°C would not show these facts with sufficient emphasis, owing to the low content of hygroscopic water. For this reason it was decided to use the clays in the air dried state, after drying from one to five days at atmospheric temperature. In several cases the air drying was carried to constant weight, which required a week or longer.

Figure 9.—This diagram represents the brick clay No. 1, dried four and a half days at room temperature. The rate of water smoking was very rapid and in fact too rapid to show the

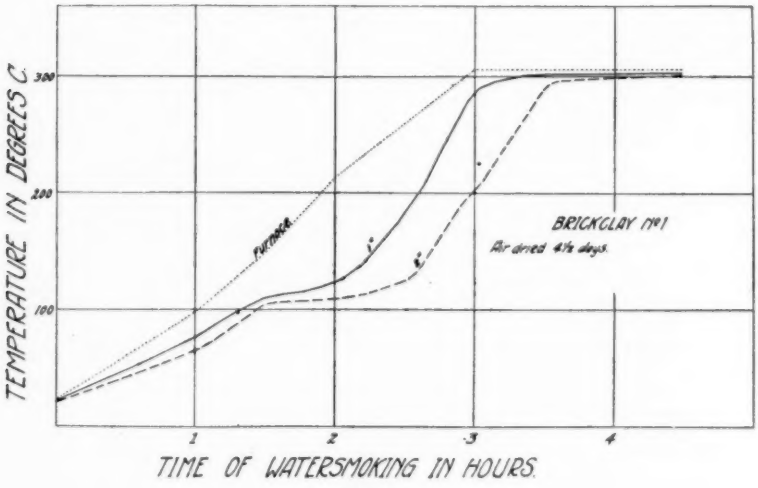


FIG. 9

critical temperature involved with sufficient accuracy. It is evident that owing to the rapid rate of heating these temperatures are displaced upwards and equilibrium between the furnace and the specimens is not attained until after prolonged heating at 300°C. As should be expected, due to the relatively high water content, the heat absorption area between the furnace curve and the clay curve is very large. There is likewise a considerable lag between the two points within the cube. From the appearance of the curves it is evident that considerable pore water is still present in the clay, since the thermal lag is apparent

from the very beginning of the heating. It would seem, however, from the configuration of the curves that the typical water-smoking temperature range lies between 100°C and some point below 300°C. For this reason it was decided to subject the same clay

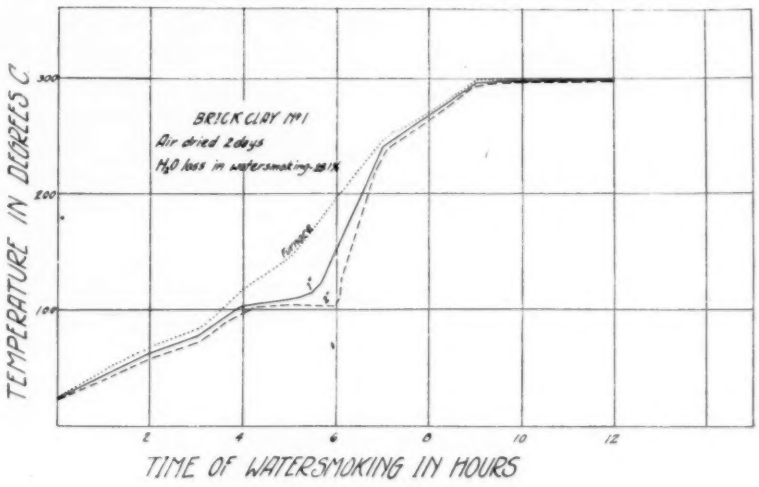


FIG. 10

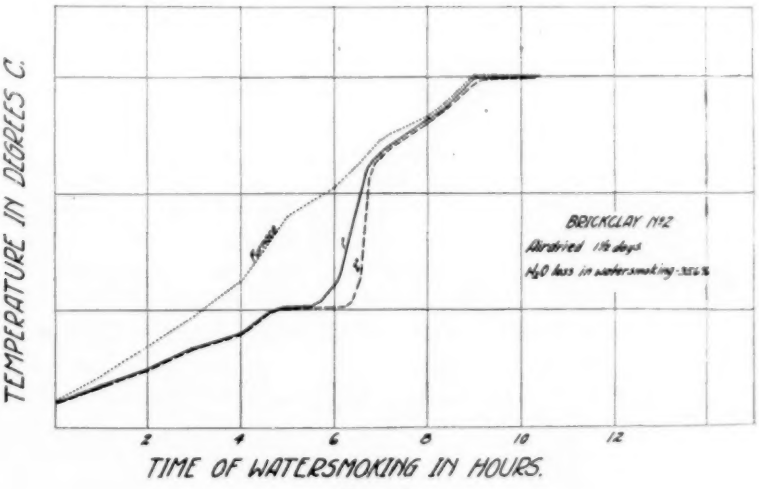


FIG. 11

specimen, dried only two days, to a less rapid heat treatment, taking nine hours to reach 300°C.

Figure 10.—Here brick clay No. 1 still containing about 28 per cent of water shows the thermal lag to lie between 100 and 240°C, which gives us the desired information for a case of this kind.

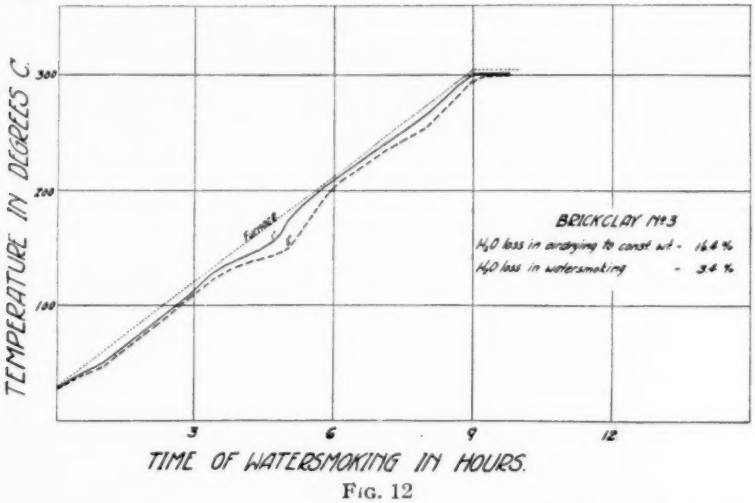


FIG. 12

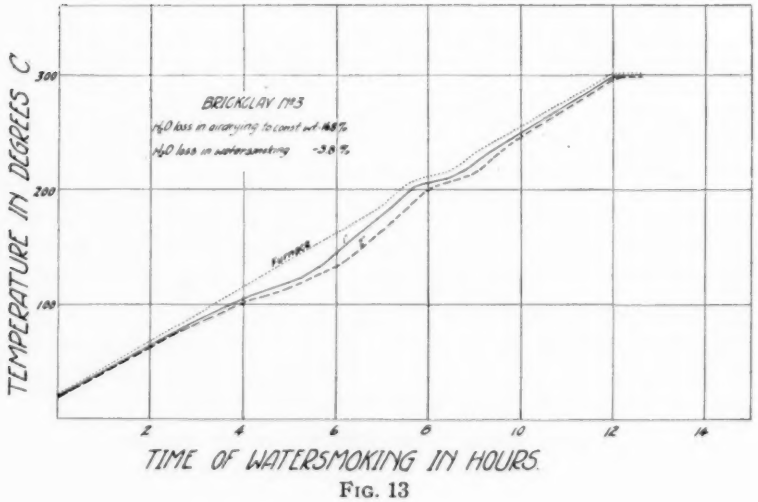


FIG. 13

Figure 11.—In this case we are dealing with brick clay No. 2 which is of the same type as No. 1 and which still contains 35.6 per cent of water. The heat absorption again, neglecting the pore water proper, is included between 100 and 240°C.

Figure 12.—This diagram represents a brick clay dried at atmospheric temperature to constant weight and then subjected to a water-smoking treatment of nine hours. The lower heat absorption limit is found to be above 100°C and the upper one at approximately 250°C.

Figure 13.—This diagram represents again brick clay No. 3, previously air dried to constant weight and still containing 3.8

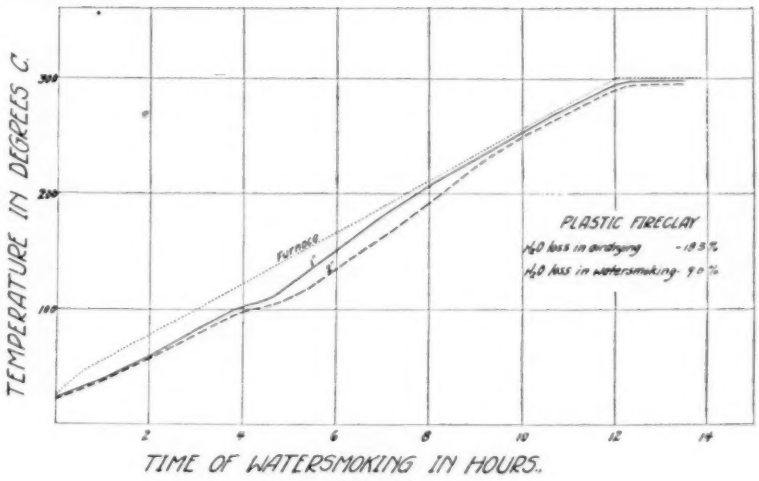


FIG. 14

per cent of water, the rate of heating being slowed down and the heat treatment extended to 12 hours. Here the temperature lag is included between 100° and approximately 240°C, and it would seem that this point is independent of any previous drying treatment to which the clay has been subjected. Since the lag between the furnace and the clay temperature is not excessive and hence not likely to cause inordinate strains, it appears that 12 hours time is required to expel the hygroscopic water.

Figure 14.—In this diagram we have the plastic fire-clay with a water content of 9 per cent at the beginning of the water smoking.

From this greater content of water it would appear that there must be considerable lag between the furnace temperature and that of the cube as well as between the two points within the latter. Owing to the presence of pore water the heat absorption must obviously extend to a point below 100°C, while the heat absorption due to the hygroscopic water is again included between 100 and 240°C.

Figure 15.—In this diagram and the one following, extreme cases were taken in which the air drying was conducted only through one day and through a half day, respectively. In the

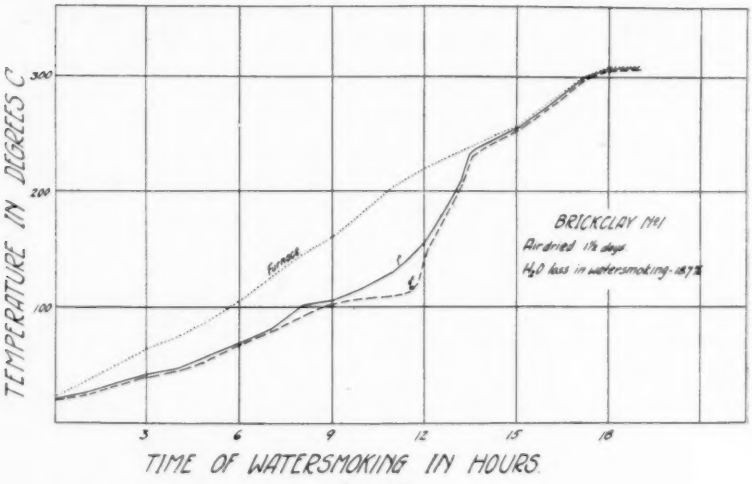


FIG. 15

present case (brick clay No. 1) the material still contained 18.7 per cent of water. The heating was conducted at quite a slow rate, covering 18 hours. It is evident that in this case there is considerable overlapping in the expulsion of the pore and hygroscopic water since the former could not be completely driven off in the time allowed before reaching 100°C. The thermal lag, therefore, is very large and the test specimen must necessarily have been subjected to a decided strain. However, the critical temperatures are again, as indicated before, between 100 and approximately 240°C. It is interesting to note that even under these conditions the water smoking was completed in about $13^1/_2$ hours.

Figure 16.—In this diagram we again have the silicious fireclay but air dried only for one day with the result that the temperature lag and the area of heat absorption are very marked. Overlapping of the evaporation of pore and hygroscopic water again occurs and there is a decided drop in temperature between

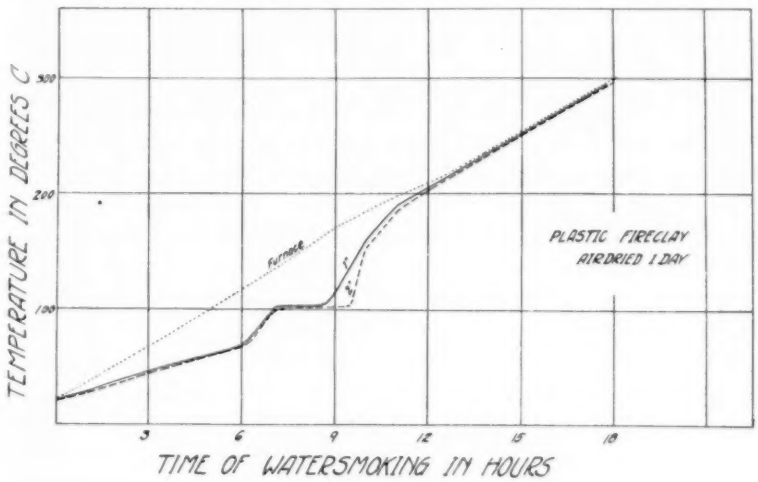


FIG. 16

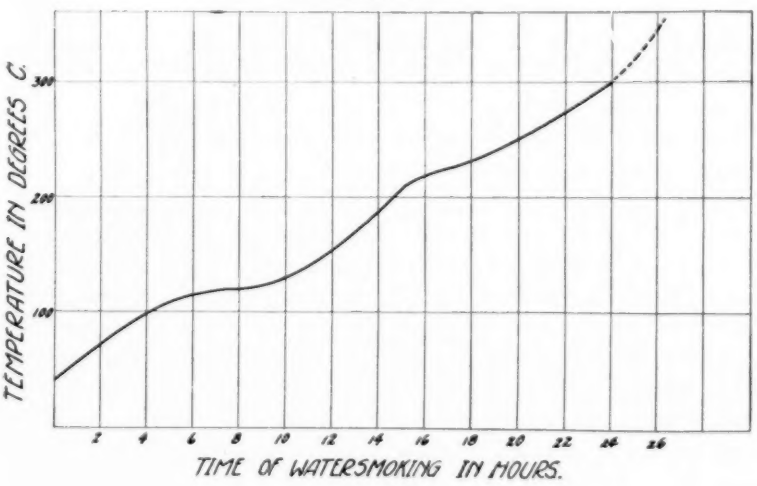


FIG. 17

the surface and the interior of the test piece, a condition which is obviously objectionable but would not have occurred if the clay had been previously dried sufficiently.

Conclusions.—From this work the following conclusions may be drawn:

For the purpose of expediting the water smoking of clay products, it is necessary to dry the ware thoroughly and as close to 100°C as possible, a statement which agrees with practical experience. It is also obvious that the permissible rate of drying is a function of the surface of the product referred to unit volume. In other words, thin ware can be dried very much more rapidly than products of heavy cross section. The four-inch cubes employed in this study are comparable with the heavier clay products such as bricks.

It is necessary, in water smoking as rapidly as possible, that the steam which is produced be removed promptly. In practice a great deal of time is lost due to the poor circulation prevailing in the kiln at the beginning of the burn. The importance, therefore, of having ample stack draft through the use of higher chimneys or such which are kept heated at the beginning of water smoking is evident. Our down draft kilns, for instance, invariably suffer from very poor initial draft, a condition which is paid for by the loss of valuable time. Not only is the water smoking process proper retarded by the deficiency in draft but it may be greatly lengthened through the absorption of steam by the ware in the cooler portion of the kiln. Such a condition greatly aggravates matters since, so to speak, a new start must be made in order to expel the accumulated excess water taken up by part of the kiln charge. It would be a good investment, therefore, to provide, if necessary, mechanical draft through the use of portable exhausters. The rate of raising the temperature during the water smoking should be such that there is no marked difference between the kiln temperature and that of the interior of the product. An excessive rate of heating invariably causes strains which may lead to damaging of the ware. The permissible rate of heating varies somewhat with the clay structure, that is, with the amount of hygroscopic water carried by the clay and with the artificial structure imparted to the material in pressing.

It is evident that clay particles possessing but limited cohesion, as in dry pressed ware, can not withstand the strain brought about by a decided temperature difference between the exterior and the interior temperature of the ware. Very slow drying becomes imperative in such a case. However, in the case of plastic clays previously dried sufficiently, it would seem that the water smoking should be completed in 15 hours when heated to 300°C, or at the rate of 20°C per hour. Provided that adequate circulation is maintained there is no reason why this should not be done, even in the case of heavy clay products. The industrial importance of this statement is apparent and is worthy of careful consideration.

The temperature range of water smoking lies between 100 and approximately 240°C for properly dried material. Overlapping of the heat absorption ranges involving the pore and hygroscopic water occurs upon insufficient drying.

Allowing 24 hours for the completion of water smoking, satisfactory results may be obtained by increasing the temperature at the rate of about 12°C per hour, or by following such a heating curve as is suggested in the diagram of figure 17. The use of base metal thermocouples is, therefore, strongly recommended for the proper control of this important process.

The writer desires to acknowledge the help of Mr. A. V. Bleininger in outlining this work and reporting the results.

Bureau of Standards
Washington, D. C.

REFRACTORIES FOR OIL-FIRED FURNACES AND BOILERS[1]

By W. H. Grant

ABSTRACT

The failure of fire-brick in oil fired furnaces results from (1) *spalling* and falling of side wall bricks, (2) *disintegration* of bricks in direct path of flame, (3) *glazing* of surface with green glaze which penetrates and weakens brick, and (4) *erosion* by flame. A plea is made for more research in the field.

The question as to the proper grade of refractory material for use in connection with oil burning furnaces of various types deserves more attention than it has apparently received in the past. So far as the writer has been able to learn, very little has been written on this subject and no great amount of research work has been done. In some localities and in some lines of industry, fuel oil has practically replaced coal, natural gas and other fuels, while in others where the cost of oil is high and coal and gas are cheap and easily obtained, the use of fuel oil is more limited. A recent report made by the Geological Survey discloses that between April 1, 1919, and March 1, 1920, the coal consumption displaced in 317 electric utility plants and 2347 industrial plants was approximately 1 per cent. The electric utility plants mentioned represent about 50 per cent of the total consumption of electric utilities and the 2347 industrials represent about 37 per cent of the total consumption of general industries, excluding steel mills and by-product coke plants.

While it is true that only a small per cent of the fire-brick and other refractory material consumed go into oil fired furnaces, nevertheless the question of the proper refractory for this class of service is of vital importance to the plant or power house operating with oil. This question is equally important to the manufacturer who is endeavoring to furnish the refractory material used. Doubtless all manufacturers of fire-brick have been called upon at some time or other to furnish a lining for an oil burner and they may have met with fair success or otherwise. I doubt very much, however, if these same manufacturers can point out definitely just why the particular brick they furnished was suitable for the job in question, or why another of their brands

[1] Received March 10, 1921.

would not have answered just as well or perhaps better. I doubt if they can answer conclusively why they furnished a handmade brick instead of one made by machine or why a dense, tough, hard-burned brick instead of a softer brick of open porous structure or vice versa. And yet what manufacturer will refuse to furnish a brick for this purpose when called upon to do so? They will, to be sure, do the best they can to supply the requirements of the purchaser, but in many instances their selection is no more than a wild guess.

The question then seems to be, "Why is an 'oil-brick,'" or in other words, "What properties must a brick have to make it suitable for use in oil-fired furnaces?" Before answering this question there are several other questions to be taken into consideration. Why do side wall bricks spall and drop out of place, thus weakening the wall? Why do the brick in the direct path of the flame become lifeless, disintegrate and fall to pieces after being in service but a short time? What it is in the oil flame itself or in the atmosphere of the combustion chamber that glazes over the outer surfaces of the brick work in some places and permeates the brick in others, causing high discoloration and probably some disintegration? Why are some brick badly eroded and flame cut in the direct path of the flame while others of approximately the same refractoriness are not affected? These and a number of other questions are presented to the man who is called upon to investigate the fire-brick service conditions in industrial plants where the brick are not proving satisfactory.

Very frequently the fault lies with the design of the furnace or with the method of operation but it is a very difficult proposition to place the blame when the refractories are going bad. The refractories manufacturers' best safeguard in all cases is to make a thorough and comprehensive study of the service conditions under which his products are to be used and then to supply material best suited to this work. A manufacturer must determine from practical experiments which of his grades of brick are most suitable—whether handmade or machine made, whether dense or porous, whether coarse ground or fine and whether burned soft or hard. Some brick made by hand, ground fairly fine, and burned hard, give excellent results in some installations,

while other brick of equal refractoriness composed of different clays and manufactured by machinery, ground fairly coarse and of a so-called medium burn, appear equally satisfactory.

The writer recently had the opportunity of inspecting a large water tube boiler installation which was equipped with one of the newer types of fuel oil burners. In order to run comparative service tests, three different boilers of the same capacity and of identical setting-design were lined with three different brands of high duty brick, which were known to the trade as being suitable for oil furnaces. So far as the writer was able to learn, all these brick had been used quite extensively in connection with oil furnaces and had proven satisfactory, but at the time of the investigation all three of these brands in the different boilers had failed badly.

The side walls had spalled off to a depth of several inches, allowing the super-structure to settle. Particles of brick which had fallen out were badly discolored by gases or vapors which had penetrated to the interior of the brick. All other parts of the side wall were glazed over with a beautiful deep greenish blue glaze which rivaled art pottery decoration. The bridge-wall was flame cut and pitted to some extent though there was evident no sign of actual fusion, although the temperature in the combustion chamber was reported to exceed 3000°F. by pyrometer determination.

One brand of brick was a machine-made brick of open structure and rather soft burn from the Missouri fire-brick producing district and the other two were Pennsylvania handmade brick of medium grain—one hard burned and the other considerably softer. In all three bricks, however, the results were practically the same. The writer has thus far not been able to answer the "why" in this case, nor has the chief engineer of the plant under whose immediate supervision these tests were conducted.

This experience is just a sample of the problems which confront the manufacturers and the consumers of "oil brick" and clearly demonstrates the necessity of intelligent research work in this field. It is the writer's candid opinion that the Refractories Division of the American Ceramic Society should go into this question and have at least one good paper prepared and read before the next general meeting.

NATIONAL REVIEW OF THE SAGGER SITUATION[1]

By George Simcoe

ABSTRACT

A questionnaire sent to a number of clay mfgs. elicited the information: (1) better *sagger cost system* needed; *carborundum* and Na SiO are frequent constituents of the sagger body; (3) jaw crusher better than pan grog; (4) sagger containing 30 per cent carborundum and lasting 20 or more fires is economical.

Having sent a questionnaire to a number of clay-ware manufacturers throughout the United States, I have listed their replies to the twenty-five questions in a chart form, grouped as follows:

2 Spark Plugs
6 Wall and Floor Tile
3 Sanitary Ware
4 General Ware
2 Vitrified China
2 High Tension Insulators
1 Art Pottery
1 Chemical and Scientific Porcelain
3 Grinding Wheels and Abrasives
4 Electric Porcelain

Ten Points Noted From the Above Chart

No. 1. Out of 28 answers only 11 give average sagger cost. It looks as if we should have a better sagger cost system. One sanitary pottery reports sagger cost 18 cents.

No. 2. The addition of 10 to 30 per cent carborundum is quite common just now. See samples 6–10–20.

No. 3. The addition of sodium silicate reduces the amount of water necessary to make plastic and gives strength to the dried sagger before firing. See samples 6A–10A–20A.

No. 4. A cast sagger having sodium silicate and carborundum incorporated. See sample.

No. 5. Jaw crusher better than pan grog. See sample grog.

No. 6. Why does the introduction of carborundum increase the life of the sagger?

[1] Received March 10, 1921.

1. Ware Manufactured?	Spark Plugs	
	1	2
2. Kind of kiln?	10″ D Dft.	Con. tunnel
3. Fire to what cone?	Cone 9	Cone 17
4. How long cool?	50 hrs.	24 hrs.
5. How make saggers, hand or machine?	Hand	Hand
6. If machine, split or solid ring?	.....	.....
7. Do you level or finish machine made saggers?	.....	.....
8. Do you make saggers day, wk., or pc. wk.?	Day work	.....
9. Do you wash saggers day, wk., or pc. wk.?	Not washed	.....
10. Are saggers bone dry when fired?	Air dry	Bone dry
11. Do you fire any ware in green saggers? If so, what part of full load?	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides & bottom)	10″ dia., 4″ high, 7/8″ thick, cost, ...	15″dia.,3 1/2″ high, cost ....
13. Average weight of ware per sagger?	8 lbs.	.....
14. Average number fires sagger lasts?	No record	50
15. Average % sagger loss?	No record	.....
16. Sagger body: % Plastic, cost inc. frt.	1/3 P $15.00 T	
% Sandy, cost inc. frt.	1/3 S 12.50	.....
% Grog, cost inc. frt.	1/3 G	
17. What % of grog is: Coarse	1/3–3/16 to 1/4	
Fine	1/3 medium	.....
Dust	1/3 dust	
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	Carborundum
19. Do you use any sodium silicate in sagger body?	No	No
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	.....
21. What pug mill do you use?	Dry grind clay and mix in box	.....
22. Do you pug twice?	.....	.....
23 Do you have a special foreman in charge of sagger dept.?	No	.....
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	.....
25. If you had the money and facilities what would you do to improve your saggers?	Expect to put in wet pan and pug mill	.....

Wall and Floor Tile

1. Ware Manufactured?	Wall and Floor Tile					
	1	2	3	4	5	6
2. Kind of kiln?	Rd. D. Dft.	14′ Dft.	Up & D. Dft.	Rd. D. Dft.	Rd. D. Dft.	D. Dft.
3. Fire to what cone?	Cone 11	Cone 1, 6, 9 and 12	Cone 10	Cone 11	Cone 11	Cone 11 D
4. How long cool?	5 days	60 hrs.	3½ to 4 da.	2 to 3 da.	2 to 3 da.	72 hrs.
5. How make saggers, hand or machine?	Machine	Hydraulic Press	Machine	Machine	Machine	Machine
6. If machine, split or solid ring?	Solid	Split	Solid	Split	Solid	Solid
7. Do you level or finish machine made saggers?	Remove rough edges—dry	Level & finish with great care	Yes	Level only	No	No
8. Do you make saggers day, wk., or pc. wk.?	Pc. wk.	Day wk.	Day wk.	Pc. wk.	Day wk.	Day wk.
9. Do you wash saggers day, wk. or pc. wk.?	Pc. wk.	Day wk.	Day wk.	Pc. wk.	Day wk.	Day wk.
10. Are saggers bone dry when fired?	Not always	Bone dry	Yes	No	Not always	No
11. Do you fire any ware in green saggers? If so, what part of full load?	No	No	No	Yes, ½	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides & bottom)	15″ x 9″ x 5½″ Cost 30 c.	16″ x 11½″ x 7¾″ ¾″ thick Cost —	17½″ x 9″ x 7½″ Side 1″ Bottom ⅞″ Cost 50 c.	14″ x 8½″ x 6″ Cost —	12″ x 8″ x 6″ 1″ thick Cost —	13″ x 8″ x 5¼″ Cost —
13. Average weight of ware per sagger?	17 lbs.	28 lbs.	33 lbs.	25 lbs.	30 lbs.	40 lbs.
14. Average number fires sagger lasts?	11 fires	8—Cone 9 7—Cone 12 12—Cone 1	No record	5 fires	6 to 8 fires	5 fires
15. Average % sagger loss?	5%	9%	5 to 7% coal 1½ to 2% gas	15%	10 to 15%	20%
16. Sagger body: % Plastic, cost inc. frt.	24% P. $10.35	40% P. $8.50	17% p. $8.00	20% P. $8.00	50% P. $7.00	33⅓% P. 8.00
% Sandy, cost inc. frt.	28% S. 10.35	20% S. 6.25	33% S. 7.50	30% S. 8.00	0% S. —	16⅔% S. 8.80
% Grog, cost inc. frt.	48% G. 2.00	40% S. 1.25	50% G. —	50% G. —	50% G. —	50% G. —
17. What % of grog is: Coarse	30% coarse on 10 40% medium	65% coarse	All 10 mesh or over	50% coarse	Not screened	100% coarse
Fine	30% fine	35% fine		50% fine		
Dust	0% dust	No dust				

1. Ware Manufactured?	Spark Plugs	
	1	2
2. Kind of kiln?	10″ D Dft.	Con. tunnel
3. Fire to what cone?	Cone 9	Cone 17
4. How long cool?	50 hrs.	24 hrs.
5. How make saggers, hand or machine?	Hand	Hand
6. If machine, split or solid ring?	.....	.....
7. Do you level or finish machine made saggers?	.....	.....
8. Do you make saggers day, wk., or pc. wk.?	Day work	.....
9. Do you wash saggers day, wk., or pc. wk.?	Not washed	.....
10. Are saggers bone dry when fired?	Air dry	Bone dry
11. Do you fire any ware in green saggers? If so, what part of full load?	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides & bottom)	10″ dia., 4″ high, 7/8″ thick, cost, ...	15″dia.,3 1/2″ high, cost ....
13. Average weight of ware per sagger?	8 lbs.	.....
14. Average number fires sagger lasts?	No record	50
15. Average % sagger loss?	No record	.....
16. Sagger body: % Plastic, cost inc. frt.	1/3 P $15.00 T	
% Sandy, cost inc. frt.	1/3 S 12.50	.....
% Grog, cost inc. frt.	1/3 G	
17. What % of grog is: Coarse	1/2–3/16 to 1/4	
Fine	1/3 medium	.....
Dust	1/3 dust	
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	Carborundum
19. Do you use any sodium silicate in sagger body?	No	No
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	.....
21. What pug mill do you use?	Dry grind clay and mix in box	.....
22. Do you pug twice?	.....	.....
23 Do you have a special foreman in charge of sagger dept.?	No	.....
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	.....
25. If you had the money and facilities what would you do to improve your saggers?	Expect to put in wet pan and pug mill	.....

1. Ware Manufactured?	Wall and Floor Tile					
	1	2	3	4	5	6
2. Kind of kiln?	Rd. D. Dft.	14′ Dft.	Up & D. Dft.	Rd. D. Dft.	Rd. D. Dft.	D. Dft.
3. Fire to what cone?	Cone 11	Cone 1, 6, 9 and 12	Cone 10	Cone 11	Cone 11	Cone 11 D
4. How long cool?	5 days	60 hrs.	3½ to 4 da.	2 to 3 da.	2 to 3 da.	72 hrs.
5. How make saggers, hand or machine?	Machine	Hydraulic Press	Machine	Machine	Machine	Machine
6. If machine, split or solid ring?	Solid	Split	Solid	Split	Solid	Solid
7. Do you level or finish machine made saggers?	Remove rough edges—dry	Level & finish with great care	Yes	Level only	No	No
8. Do you make saggers day, wk., or pc. wk.?	Pc. wk.	Day wk.	Day wk.	Pc. wk.	Day wk.	Day wk.
9. Do you wash saggers day, wk. or pc. wk.?	Pc. wk.	Day wk.	Day wk.	Pc. wk.	Day wk.	Day wk.
10. Are saggers bone dry when fired?	Not always	Bone dry	Yes	No	Not always	No
11. Do you fire any ware in green saggers? If so, what part of full load?	No	No	No	Yes, ½	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides & bottom)	15″ x 9″ x 5½″ Cost 30 c.	16″ x 11½″ x 7¾″ ¾″ thick Cost —	17½″ x 9″ x 7½″ Side 1″ Bottom ⅞″ Cost 50 c.	14″ x 8½″ x 6″ Cost —	12″ x 8″ x 6″ 1″ thick Cost —	13″ x 8″ x 5¼″ Cost —
13. Average weight of ware per sagger?	17 lbs.	28 lbs.	33 lbs.	25 lbs.	30 lbs.	40 lbs.
14. Average number fires sagger lasts?	11 fires	8—Cone 9 7—Cone 12 12—Cone 1	No record	5 fires	6 to 8 fires	5 fires
15. Average % sagger loss?	5%	9%	5 to 7% coal 1½ to 2% gas	15%	10 to 15%	20%
16. Sagger body: % Plastic, cost inc. frt.	24% P. $10.35	40% P. $8.50	17% p. $8.00	20% P. $8.00	50% P. $7.00	33⅓% P. 8.00
% Sandy, cost inc. frt.	28% S. 10.35	20% S. 6.25	33% S. 7.50	30% S. 8.00	0% S. —	16⅔% S. 8.80
% Grog, cost inc. frt.	48% G. 2.00	40% S. 1.25	50% G. —	50% G. —	50% G. —	50% G. —
17. What % of grog is: Coarse	30% coarse on 10 40% medium	65% coarse	All 10 mesh or over	50% coarse	Not screened	100% coarse
Fine	30% fine	35% fine		50% fine		
Dust	0% dust	No dust				

1. Ware Manufactured?	Wall and Fall Tile					
	1	2	3	4	9	6
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	No	No	No	No	No
19. Do you use any sodium silicate in sagger body?	No	No	No	No	No	No
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	No	No	No	No
21. What pug mill do you use?	Fate auger brick mach.	Crossley vertical pug	Patterson vertical pug	Horizontal	Vertical	Patterson pug mill
22. Do you pug twice?	No	Yes	Yes	No	Yes	Yes
23. Do you have a special foreman in charge of sagger dept.?	Yes	Yes	No	Yes	No	Yes
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	No	No	Yes—could see no difference	No	No
25. If you had the money and facilities what would you do to improve your saggers?	Have completed improved installation & anticipate desired results	See Note "A"	Use several plastic clays instead only one now used. "See Note B"	See Letter "C"	Will start in near future to use carborundum or some other such material	Use carborundum in sagger body

Note "A"—(1) Build enough pits to temper each mix at least seven days before pugging.
(2) Concrete bins to age mix two weeks after second pugging before pressing.
(3) Storage facilities to weather and age clays six months.

Note "B"—The writer attempted sometime ago to arrive at some theoretical results but was lost in a mass of valueless data, and concluded that practical observation gave better results. You are to be commended upon this endeavor as I believe through a clearing of such information as you request, the most valuable data can be had.

Letter "C"—A factory would be justified in expending any amount of money to enable them to make a better sagger if they knew where and how to spend it. Saggers are the heart and life and are necessary to the profitable operation of any clay plant that uses them, and if out of all the discussions and experiences of our members, a solution can be found, and we can be led out of the wilderness, the "Children of Israel" will have nothing on us, and the existence of the American Ceramic Society will be justified.

Sanitary

LETTER "C"—A factory would be justified in expending any amount of money to enable them to make a better sagger if by so doing they could reduce the cost of the sagger to the point where it would pay them to spend it. Saggers are the heart and life and are necessary to the profitable operation of any clay plant that uses them, and if out of all the discussions and experiences of our members, a solution can be found, and we can be led out of the wilderness, the "Children of Israel" will have nothing on us, and the existence of the American Ceramic Society will be justified.

1. Ware Manufactured?	Sanitary		
	1	2	3
2. Kind of kiln?	Dd. Up Dft.	Rd. D. Dft.	6 Periodic, 1 Dressler tun.
3. Fire to what cone?	Cone 10	Cone 8	Cone 10 Per. Cone 8 Tun.
4. How long cool?	64 hrs.	60 hrs.	24 hrs.
5. How make saggers, hand or machine?	Hand and machine	Machine	Cast in moulds
6. If machine, split or solid ring?	Split	Split	.....
7. Do you level or finish machine made saggers?	Yes	Yes	.....
8. Do you make saggers day, wk., or pc. wk.?	Day wk.	Day wk.	Day wk.
9. Do you wash saggers day, wk , or pc. wk.?	Day wk.	Day wk.	Day wk.
10. Are saggers bone dry when fired?	Yes	No	Yes
11. Do you fire any ware in green saggers? If so, what part of full load?	No	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides and bottom)	18″ x 25″ x 11″ 1″ thick Cost —	Oval, 24″ x 18″ x 3/4″ thick Cost 18 c.	22″ x 18″ x 11″ 7/8″ thick Cost —
13. Average weight of ware per sagger?	50 lbs.	40 lbs.	40 lbs.
14. Average number fires sagger lasts?	6 fires	8 fires	15 to 20 fires
15. Average % sagger loss?	Bis. 25%, Glost 5%	.....	.....
16. Sagger body: % Plastic, cost inc. frt.	57% P. 12.90	40% P.	25% P. 8.50
% Sandy, cost inc. frt.	43% G. —	60% G.	25% S. 9.00
% Grog, cost inc. frt.			25% G. — 25% Carbor.
17. What % of grog is: Coarse	On 4 M—35%	Take all	50% coarse
Fine	Bet. 4 & 7—20 1/2%		50% fine
Dust	Bet. 7 & 14—14 1/2% Bet. 14 & 32—22% Through 32–8%		
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	No	Carborundum
19. Do you use any sodium silicate in sagger body?	No.	No	Yes
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	No
21. What pug mill do you use?	Vertical	Crossley	Raymond
22. Do you pug twice?	Yes	Yes	Yes
23. Do you have a special foreman in charge of sagger dept.?	No	No.	No

Ware Manufactured?	Sanitary		
	1	2	3
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	No	No
25. If you had the money and facilities what would you do to improve your saggers?	Not able to secure satisfactory uniformity & quality of clays from shippers	Slop mixing	Do not see much hope of improvement

1. Ware Manufactured?	General Ware			
	1	2	3	4
2. Kind of kiln?	Up Dft.	Down Dft.	D. and Up Dft.	Up Dft. Periodical
3. Fire to what cone?	Cone 9	Cone 8	Cone 9 Bis. Cone 6 Glost	Cone 8
4. How long cool?	48 hrs.	15 hrs. before D. Dft.	3 da. Bis. 2 da. Glost	60 hrs. Bis. 36 hrs. Glost
5. How make saggers, hand or machine?	Hand	Hand & machine	Hand	Pin-hand Common-mach.
6. If machine, split or solid ring?	.....	Split	.....	Solid
7. Do you level or finish machine made saggers?	.....	Yes	.....	Yes
8. Do you make saggers day, wk., or pc. wk.?	Pc. wk.	Day wk.	Pc. wk.	Pc. wk.
9. Do you wash saggers day, wk., or pc. wk.?	Pc. wk.	Day wk.	Pc. wk.	Pc. wk.
10. Are saggers bone dry when fired?	Yes	No—but could	Yes	No
11. Do you fire any ware in green saggers? If so, what part of full load?	Yes—1/4 load	Yes—2 spittoons in sag.	Yes—1/4 load	Yes—1/4 load
12. Give average size, shape & cost of sagger used. (Thickness, sides & bottom)	..... Cost —	..... Cost —	..... Cost —	Standard—3/4" thick Cost 80 c.
13. Average weight of ware per sagger?	.....	.....	.....	Glost 9 lbs

	Cost —	Cost —	Cost —	thick Cost 80 c.
13. Average weight of ware per sagger?	.....	.....	.....	Glost 9 lbs. Bis. 20 lbs.
14. Average number fires sagger lasts?	10 to 12 fires	10 fires	16 fires	12.5 fires
15. Average % sagger loss?	10 to 12%	.....	.....	8%
16. Sagger body: % Plastic, cost inc. frt.	30% P.	30% P.	28% P.	50% P. 11.00
% Sandy, cost inc. frt.	20% S.	30% S.	18% S.	50% G. —
% Grog, cost inc. frt.	50% G.	40% G.	54% G.	
17. What % of grog is: Coarse	50% coarse	All medium	No data	Coarse, 4 M—10%
Fine	30% fine			10 M—75%
Dust	20% dust			16 M—10%
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	No	Experimenting	Some carborundum
19. Do you use any sodium silicate in sagger body?	No	No	No	No
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	No	No
21. What pug mill do you use?	Patterson Upright	Upright	Vertical	Patterson
22. Do you pug twice?	Yes	Yes	Yes	Yes
23. Do you have a special foreman in charge of sagger dept.?	No	Yes	No	No
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	No	No	No
25. If you had the money and facilities what would you do to improve your saggers?	.....	.....	See Letter "D"	Dry saggers, bone dry; size all grog; disintegrate clays; mix in wet pan

LETTER "D"—Referring to Question No. 25, the most important improvement to my mind which could be adopted in the average sagger house would be a more accurate and better method of mixing and preparing our clay. We are about to remodel our sagger house and treat our clay in the following manner: All sagger clay will be kept under cover and stored as far as possible when dry. The clay will be mixed as usual in wheelbarrows and afterwards passed through crushers and finely pulverized. From the crusher, the clay will fall into a pit. The grog will be ground on the ordinary grog-panel but instead of its falling as it does now direct on the floor, it will fall on piano wire screen and all of the dirt be extracted. The grog will then fall into a pit similar to the clay. These pits will be located on each side of the horizontal pug mill. Both the clay and the grog will be delivered simultaneously by continuous bucket elevators delivering into the mouth of the pug. The speed of these bucket elevators may be varied to give different proportions of clay and grog. Simultaneously a continuous stream of water regulated to the correct flow will fall into the mouth of the pug. In this manner you will realize that we will get a very much more intimate mixture of clay and grog, and the clay will carry a higher percentage of grog and the consistency of the clay will be uniform. The preparation of the clay will be quicker and cheaper. The present method of putting the clay in pits in more or less lump form and in layers with the grog is, in my opinion, poor and obsolete.

It may interest you to know that in connection with the Watson Stillman sagger machine which we are about to install, we have designed and are having built an automatic machine for punching the pin holes in glost saggers. This, so far as we know, is new and will make the entire operation of sagger making for general ware plants automatic and without skilled labor. Further than this, our plans incorporate an automatic conveying stove in which saggers, which have to be dried out completely and not punched, can be dried well and quickly by the humidity temperature control system. Each sagger will be drawn from the machine on a perfectly straight steel plate which will allow the bottom to dry equally with the sides and also form a level support for the bottom of the sagger.

If this description is not clear and if there is any further information I can give you, kindly advise me.

1. Ware Manufactured?	Vitrified China		High Tension Insulators		Art Pottery
	1	2	1	2	1
2 Kind of kiln?	Up Dft.	Up & D. Dft.	Up Dft.	Up Dft.	Down Dft.
3. Fire to what cone?	Cone 10 Bis. Cone 3 Glost	Cone 11 Bis. Cone N6 Glost	Cone 11	Cone 11	Cone 7
4. How long cool?	3½ da. Bis. 2½ da. Glost	50 hrs.	36 hrs.	60 hrs.	60 hrs.
5. How make saggers, hand or machine?	Hand & machine	Hand & machine	Machine, steam	Hand & machine	We buy our saggers
6. If machine, split or solid ring?	Solid	Solid	Solid	Solid	.....
7. Do you level or finish machine made saggers	Yes	Yes	No	Leveled but not finished	.....
8. Do you make saggers day, wk., or pc. wk.?	Mach., da. wk. Hand, pc. wk.	Pc. wk.	Day wk.	Day wk.	.....
9. Do you wash saggers day, wk., or pc. wk.?	Day wk.	Day wk.	Day wk.	Day wk.	.....
10. Are saggers bone dry when fired?	Not quite	Not always	Yes	Commercially dry	.....
11. Do you fire any ware in green saggers? If so, what part of full load?	Yes—¼ load	Yes—20%	Yes—½ load	Yes—light pcs. around outer edge—¼ ld.	.....
12. Give average size, shape & cost of sagger used. (Thickness, sides & bottom)	14″ x 21″ ¾″ side ⅛″ bottom	Oval—⅜″ thick Banjo—13″ x 16″	Rd.—14″ dia. Oval—14″ dia. Side ⅝″ Bottom 1″	16″ x 8″ high 18″ x 9″ high 18″ Rd. cost 64 c. 16″ Rd. cost 40 c	18″ rd x 5″ high x ¾″ thick
	Cost —	Cost —	Cost 22½ c.	Av. cost 35 c.	Cost 50 c.
13. Average weight of ware per sagger?	.....	30 lbs.	13½ lbs.	13 to 14 lbs.	5 lbs.
14. Average number fires sagger lasts?	Bis. 15 to 20 Glost 5 to 10	8 to 9 fires	6 fires	20 fires	16 fires
15. Average % sagger loss?	Bis. 5 to 10% Glost 10 to 20%	10%	14%	5%	.....
16. Sagger body: % Plastic, cost inc. frt.	33% P. —	20% P. —	40% P. 11.00	20% P. 9.83	
% Sandy, cost inc. frt.	23% S. —	30% S. —	17% S. 11.00	30% S. 11.87	.....
% Grog, cost inc. frt.	44% G. —	50% G. —	43% G. —	50% G. 6.50	

% Grog, cost inc. frt.	44% G. —	50% G. —	43% G. —	50% G. 6.50	
17. What % of grog is: Coarse	All coarse	50% coarse	50% coarse	Do not sift grog	.....
Fine		50% fine	50% fine		
Dust		0% dust	0% dust		
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	Carbor. 2%	No	No	.....
19. Do you use any sodium silicate in sagger body?	No	No	No	No	.....
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	No	Small amount porc. dust scrap	.....
21. What pug mill do you use?	Vertical	Old Type	Patterson	Bonnot Horizontal	.....
22. Do you pug twice?	Yes	Yes	Yes	No	.....
23. Do you have a special foreman in charge of sagger dept?	No	No	Yes	No	.....
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	Jaw crusher better than pan grog	No	No	.....
25. If you had the money and facilities what would you do to improve your saggers?	Put clay thru crusher	Fire in special kilns without any filling	See Letter "E"	See Letter "F"	.....

LETTER "E"—If sufficient funds were available and production could be maintained while alterations are made, the following method of sagger manufacture would be considered:

It is a well established fact in the re-inforced concrete construction field that the compressive strength of concrete is dependent in no small degree upon the relative proportions of the different sized aggregates in the mix; in other words, assuming the ratio of the cement to the aggregate to be constant, there exists a relation between the amounts of the various sizes of aggregate which will produce the strongest concrete.

With the above fact at hand and believing that there exists an analogy between the concrete and the sagger problems, it would be a plausible idea to dispense with sandy clays and introduce more of the extremely fine grog (finer than 20 mesh). A small batch of sagger mix was made up at this plant using no sandy clay and choosing arbitrarily a relation between the different sizes of grog, the resulting saggers running an average of eleven fires while several lasted thirteen.

In the above experiment nothing but the plastic clay and grog were used and the mix was pugged four times instead of twice.

Such results warrant the installation of a set of screens to size the grog (4, 8, 16 and finer). The grog should be added to the wet pan for mixing with the clay, preventing any grinding by elevating the mullers $^3/_4$" above the bottom of the pan. The remainder of the tempering water should then be added and the entire batch allowed to mix for from five to eight minutes, thus accomplishing or bringing about a uniformity which can not be obtained by six or seven puggings. After one day's ageing, the mix should be in proper condition for pugging out into the bats suitable for the sagger press.

LETTER "F"—We are just putting in operation at Baltimore, a new factory in the equipment of which we were not restricted as to money and facilities. We would install power presses, plenty of large capacity soaking pits, sufficient dry pan equipment, etc., to enable us to make our saggers according to the most approved methods as we understand them. At this plant the grog will be sifted and the dust not used.

1. Ware Manufactured?	?	Grinding Wheels and Abrasives		
	1	1	2	3
2. Kind of kiln?	Down Dft.	Down Dft.	Down Dft.	Semi D. Dft.
3. Fire to what cone?	High enough	Cone 11	Cone 12	Cone 10 to 11
4. How long cool?	72 hrs.	5 days	6 days	7 days
5. How make saggers, hand or machine?	4/5 Mach. 1/5 Hand	Hand	Hand & Machine	Hand
6. If machine, split or solid ring?	Solid	.....	Split	.....
7. Do you level or finish machine made saggers?	No.	.....	No	.....
8. Do you make saggers day, wk., or pc. wk.?	Day wk.	Day wk.	Pc. wk.	Day wk.
9. Do you wash saggers day, wk., or pc. wk.?	Day wk.	Do not wash	No	.....
10. Are saggers bone dry when fired?	Yes	Not always	Leather hard, not bone dry	Yes
11. Do you fire any ware in green saggers? If so, what part of full load	Full load	None	No	No
12. Give average size, shape and cost of sagger used. (Thickness, sides and bottom)	Oval—7" high Wall 1" Bottom 1 1/4" Cost —	16" to 20" O. D. 2 1/2" deep 1" wall Cost —	16" x 4" Rd. 3/8" wall & bottom Cost 58 c.	14" x 6" Rd. 1 1/4" thick Unable to get cost
13. Average weight of ware per sagger?	7 lbs.	20"—30 lbs. 16"—18 lbs.	42 lbs.	25 lbs.
14. Average number fires sagger lasts?	Difficult to estimate	8 times	.....	50 fires
15. Average % sagger loss?	Less than 2%	12 1/2%	.....	.....
16. Sagger body: % Plastic, cost inc. frt	33 1/3% P. 8.00	25% P. 11 33	34% P. 13.00	33 1/3% P. 6.00
% Sandy, cost inc. frt	33 1/3% S. 8.00	25% S. 10.33	16% S. 12.00	33 1/3% S. 6.00
% Grog, cost inc. frt	33 1/3% G. 1.25	50% G. —	50% G. —	33 1/3% G. —
17. What % of grog is: Coarse	Not screened	From 4 to 20 mesh; no dust	50% coarse	Through No. 10 mesh and retained on No. 48 mesh
Fine			50% fine	
Dust			0% dust	
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	No	.....	No
19. Do you use any sodium silicate in sagger body?	No	No	No	No

20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	.....	No
21. What pug mill do you use?	Vertical	Patterson	Vertical	Home make
22. Do you pug twice?	Yes	Yes	Yes	No
23. Do you have a special foreman in charge of sagger dept.?	No	Yes	.....	No
24. Have you ever tried using a special shaped grog? If so, will you give us your experience?	No	No	.....	No
25. If you had the money and facilities what would you do to improve your saggers?	We do not know how our saggers can be improved but we are willing to learn	Improve drying & have them thoroughly dry when fired; make grog of new clays calcined & crushed	.....	.....

1. Ware Manufactured?	Electric		Porcelain	
	1	2	3	4
2. Kind of kiln?	D. Dft. Didier March tunnel	Up Dft.	Combination Up & D. Dft.	14′ Up Dft.
3. Fire to what cone?	Cone 11	Cone 12	Cone 12	Cone 10
4. How long cool?	50 hrs.	22 hrs.	48 hrs.	72 hrs.
5. How make saggers, hand or machine?	Machine	Machine	Machine	Crossley hand power machine
6. If machine, split or solid ring?	Solid	Split	Solid	Split
7. Do you level or finish machine made saggers?	No	Yes	No	No
8. Do you make saggers day, wk., or pc. wk.?	Pc. wk.	Pc. wk.	Pc. wk.	Pc. wk.
9. Do you wash saggers day, wk., or pc. wk.?	.....	Pc. wk.	Day wk.	Day wk.
10. Are saggers bone dry when fired?	No	Not always	Yes	No
11. Do you fire any ware in green saggers? If so, what part of full load?	Yes—1/2 load	Yes—1/2 load	No	Yes—50% load
12. Give average size, shape and cost of sagger used. (Thickness, sides & bottom)	12″ x 6″ Rd. 1″ thick Cost 30 c.	12″ x 4″ Rd. 1″ thick Cost 30 c.	12″ x 5 1/2″ Rd. Top & side 3/4″ Bottom 1″ Cost 30 c	13″ x 16″ Oval 1″ sides 1 1/4″ bottom Cost 32 c.

1. Ware Manufactured?	Electric		Porcelain	
	1	2	3	4
13. Average weight of ware per sagger?	20 lbs.	10 lbs.	20 lbs.	60 lbs.
14. Average number fires sagger lasts?	7 fires	6 fires	15 fires	10 fires
15. Average % sagger loss?	14%	13¾%	7%	9%
16. Sagger body: % Plastic, cost inc. frt.	30% P. 9.25	48% P. 8.00	30% P. 14.50	40% P. 10.83
% Sandy, cost inc. frt.	40% S. 10.42	S. —	30% S. 11.50	20% S. 5.85
% Grog, cost inc. frt.	30% G. —	52% G. 3.00	40% G. —	40% G. —
17. What % of grog is: Coarse	Coarse 80%	Coarse 64%	All that passes ½" and held on 8 mesh; no dust or fine	Grog screen ¼" max. and 1/16" min.
Fine	Fine 20%	Fine 31%		
Dust	Dust 0%	Dust 5%		
18. Do you use any carborundum, alundum, zircon or similar body in saggers?	No	No	No	No
19. Do you use any sodium silicate in sagger body?	No	No	No	No
20. Do you use any other materials in sagger body not mentioned? If so, what?	No	No	No	No
21. What pug mill do you use?	Crossley 24"	Logan Vertical	Patterson	Crossley Horizontal
22. Do you pug twice?	No—first mix body in wet pan	Yes	Yes	Yes
23. Do you have a special foreman in charge of sagger dept.?	Yes	No	No	No
24. Have you ever tried using a special shaped grog? If so, will you gives us your experience?	No	No	No	No
25. If you had the money and facilities what would you do to improve your saggers?	Experimenting with various clays. No definite results to reports	See Note "G"	.....	Would try wet pan

Note "G"—Would have pug mill to pug a uniform bar of clay so as to have no cracks for the oil from the sagger die to get in and have a chance to weaken the sagger in drying or firing.
Would then equip sagger shop with a high powered solid case sagger machine to do away with any chance for a feed away of clay.
Would then have the saggers hand finished or leveled before going to the dryer.

Why should a peppering with a material having a low coefficient of expansion, more or less surrounded by a material with a fairly high coefficient of expansion, give these results? See sample.

No. 7. A sagger is a good deal like a high tension insulator; *i.e.*, the preparation and manipulation of the clay—the final finishing together with careful handling and drying—is 50 per cent of the battle for good ware. Therefore, may we not suggest that the potter will take more care with a body which contains carborundum and costs four times as much as the regular sagger body.

No. 8. We have been led to expect longer life from saggers fired in continuous kilns. Yet we show 50 fires in one case, 15 to 20 in another, and only 7 in a third. Can the continuous kiln men give us light on this?

No. 9. From the chart we have made a rough analysis and average of the number of fires shown at the different cones:

Cone 1.....	12 fires	
Cone 7.....	16 fires	
Cone 8.....	10 fires	
Cone 9.....	11 fires	
Cone 10.....	19 fires	(This is high due to one report which shows 50 fires at Cone 10 and cooled 168 hrs. This is not a continuous kiln.)
Cone 11.....	8 fires	
Cone 12.....	9 fires	
Cone 17.....	50 fires	(This is a continuous kiln.)

We have also made an analysis giving the average number of fires based on the hours cooling:

24 hrs.....	20 fires	(This is high due to one report showing 50 fires at cone 17 in a continuous kiln.)
36 hrs.....	6 fires	
48 hrs.....	10 fires	
50 hrs.....	7 fires	
60 hrs.....	11 fires	
72 hrs.....	7 fires	
120 hrs.....	9 fires	
168 hrs.....	50 fires	(This is not a continuous kiln.)

No. 10. Cost of sagger body containing 30 per cent carborundum:

48% Plastic at $8.00 per T.	$ 3.84
22% Grog at $2.00 per T.	0.44
30% Carborundum at $60.00 per T.	18.00
100%	$22.28 cost per T.
Less reclaimed broken saggars	1.50
	$20.78 net cost per T.

Cost of sagger body without carborundum:

48% Plastic at $8.00 per T.	$3.84
52% Grog at $2.00 per T.	1.04
100%	$4.88 cost per T.
Less reclaimed broken saggars	1.50
	$3.38 net cost per T.

Based on the above figures we will try to show the difference in cost of 100 saggars that last 21 fires, containing carborundum, and 300 saggers lasting 7 fires each, containing no carborundum.

100 carb. sag. at 30 lbs. ea. = 3000 lbs. at $20.78 per T.	$31.17
100 carb. sag. (make, hdle. and wash)	6.47
100 carb. sag. (cost 1/2 load profit on same at 5 c. per sag.)	5.00
	$42.64

Total cost of 100 saggers containing 30 cer cent carborundum, and lasting 21 fires is $42.64.

300 sag. (no carb.) at 30 lbs. ea. = 9000 lbs. at $3.38 per T.	$15.21
300 sag. (no carb.) (make, hdle. and wash)	19.41
300 sag. (no carb.) (cost 1/2 ld. profit on same at 5 c. per sag.)	15.00
	$49.62

Total cost of 300 saggars, containing no carborundum, and lasting 21 fires is $49.62.

Based on the above figures it would be reasonable to assume that if room, efficiency, machine wear and tare be taken into consideration, 20 fires in a 30 per cent carborundum sagger would be an economy. When the grog begins to return containing carborundum still better results would be expected.

NOTE ON THE ACID RESISTANCE OF ENAMELED COOKING UTENSILS[1]

By B. T. Sweely

ABSTRACT

Apparent segregation of the constituents of an enamel under the influence of gravitation.—Experiments with trial pieces with poured samples, and with enameled ware of various mfgr's. showed that the surface of the layer of enamel which is uppermost during firing and cooling is readily attacked by acid, thus indicating, apparently, that the more soluble materials tend to rise to the top of the melt. It is therefore recommended that enameled kitchen utensils be fired in an inverted position. In the discussion by Bryan A. Rice a series of similar experiments are described using small shallow cups. Quantitative tests failed to show any difference in acid resistance and it is suggested that the author's results were due to the nature of the gases in contact with the enamel surface or to *volatilization*. In his reply the author accepts this explanation of his results.

During the development of a number of sheet steel enamels for various purposes, the writer experienced no little difficulty with inconsistent results when the enamels were applied to trials and tested for acid resistance. The test used was the application of a few drops of a ten per cent solution of citric acid[2] to the surface of the ware, allowing it to remain for ten minutes, then washing and wiping dry and noting its effect on the lustre of the enamel.

Under this test, the same enamel would frequently show widely different results, sometimes being only slightly affected, the gloss not being impaired beyond showing a slight iridescence, while in other cases the lustre was completely destroyed, a chalky white surface resulting. Both results were not encountered on the same surface but seemed to vary from piece to piece.

Attempting to get some explanation for this peculiar phenomena, a number of trial batches of various composition were melted in a small crucible and the enamels poured onto an iron slab to secure a surface for testing with the acid without the necessity of

[1] Received March 1, 1921.

[2] This Journal, **3**, 560 (1920).

making up enamel trials. The results were rather surprising in that it was found that the upper surface alone was attacked by the acid, the side next to the metal slab and all fractured surfaces being apparently wholly unaffected by the acid treatment. Pieces with fractured lower and upper surfaces were immersed in the acid solution for thirty-six hours, boiled gently for two hours, with exactly the same results, *i. e.*, the upper surface was distinctly chalked while the fractured surfaces and the surface next to the metal slab showed no evidence of attack. Repeated experiments checked this in every case, except in those enamels whose acid resistance was sufficiently high to be unaffected under any conditions by a solution of this strength and activity.

It seemed, therefore, that in the case of these trials, there was a segregation of the more soluble constituents of the enamel on the upper surface and if this could be eliminated from the surface of the enamel on the inside of a cooking utensil, the acid resistance of ware made from such an enamel would be materially improved. A number of trials were therefore made up from a formula which exhibited this phenomenon and fired upside down in the final fire. Under this condition, if this same phenomenon took place in the vessel as occurred when the glass was poured on a slab, the inside bottom of the vessel should present a surface similar to the under-surface of the glass poured on the slab and result in a better acid resisting cooking utensil than could be secured by firing in an upright position.

The results were exactly as expected, the inside bottom surfaces of the pieces fired as described above being unaffected by the acid test while the outside of the same piece was readily etched. Further trials of various enamels checked this in every instance, the ware fired upside down having a better acid resistance on the inside than on the outside in every case, and was with nearly every enamel tried wholly unaffected by a ten per cent solution of citric acid, however long the exposure. Many of these pieces were filled with the acid solution and set in another vessel containing the same acid solution, and allowed to remain for thirty-six to forty-eight hours, the result being that the outside was often distinctly chalked while the lustre of the inside was apparently unaffected. The same test was applied to the wares

of a number of different manufacturers which had obviously been fired in an inverted position in the last fire, and the same result was observed, which would seem to indicate that the results secured were not peculiar to the particular type of enamel used by the writer in this work. I regret that it is not possible to present the formulae of the enamels tested, but from the results secured, I believe anyone can duplicate this work on an ordinary sheet steel enamel unless it is much more resistant to organic acids than is usually the case.

The application of the above observations is obvious, the manufacturer need only plan to fire all cooking utensils in an inverted position in the final fire to insure a decided improvement in the acid resistance of any enamel and in most cases to render it sufficiently acid resistant to be proof against attack by the most active acid encountered in kitchen use.

CERAMIC LABORATORIES
COONLEY MANUFACTURING COMPANY
CICERO, ILLINOIS

Discussion

By BRYAN A. RICE: In an attempt to check the results obtained by Mr. Sweely, the following experiments were conducted.

Test pieces were prepared by taking our standard 3″ diameter laboratory test cups and cutting down the sides until only the bottom remained. This gave practically a flat surface, yet it had sufficient depth to hold a few cc. of acid. A cup or test piece of this type was desired because with a deep dish in an inverted position the composition and nature of the gases in contact with the enameled surface might be entirely different from that in contact with the outside of the dish due to chemical reactions taking place during burning or to volatilization of certain enamel constituents. The shape of the piece might not allow the same circulation of these gases when burned in the inverted positions as when burned upright. With a flat shape practically the same conditions would prevail above and below the piece. Twenty of these were used. Each was stenciled and then cleaned by sand blast after having been heated to red heat to drive off oil and grease.

The pieces were then sprayed with a ground coat and burned in

a small electric muffle furnace where the temperature could be easily controlled and an oxidizing atmosphere maintained. Numbers 1 to 10, inclusive, were burned in an upright position. Numbers 11 to 20 were inverted. Each piece was given the same length of time in burning at a constant temperature.

Two types of cover coats were used. One, which we will call Enamel "A," is used almost exclusively for dairy purpose and is only fairly resistant to organic acids. The other, Enamel "B," is unattacked by organic acids and is also used for dilute inorganic acids.

The number of applications of these cover coats varied, as will be shown in the table which follows. All first coats of Enamel "A" were burned the same length of time at the same temperature both for those in the upright position and those which were inverted. The same was true of Enamel "B." Likewise constant burning conditions prevailed for each successive coat.

After burning all trials were carefully weighed. 10 cc. of 10 per cent Citric Acid was placed in each dish enameled with Enamel "A." 10 cc. of 1.5 per cent Hydrochloric Acid was used for those enameled with enamel "B." This amount of acid left only a small portion of the enameled surface exposed. They were allowed to stand twenty-four hours. They were then washed, dried and weighed again.

With those enameled with "A" very little difference could be noted between the ones burned in an upright position and those which were inverted. That is, the three-coat pieces of the former checked the three-coat pieces of the latter well within limits of error since the total weight of the trials averaged 120 grams. The same is true of the four-coat pieces, while the five-coat trials checked fairly well, considering the fact that there was only one of each.

The results obtained with enamel "B" were unsatisfactory, since they were not consistent within themselves. While the averages checked in a surprising way, the data can not be considered of much value. For example, in the third coat trials burned in the inverted positions the difference in loss was greater than the loss in weight of one of the trials. The only explanation the writer has is that the acid used was too weak and the resulting losses so

small that a slight irregularity anywhere along the line during processing or subsequent treatment caused a relatively large variation in the final results.

When the trials were observed by eye all showed visible etching, but nothing was noted which did not check in with the gravimetric results.

From the above tests it would seem that the results obtained by Mr. Sweely might be due more to the nature of the gases in contact with the enamel surface or the degree of volatilization taking place, than to the segregation of the soluble constituents.

It would be interesting to hear from Mr. Sweely as to whether he found that the bottom of a piece burned in the upright position had the same resistance on the inside as the outside of the bottom of a piece burned inverted.

RESEARCH LABORATORIES
ELYRIA ENAMELED PRODUCTS CO.
ELYRIA, OHIO

AUTHOR'S CLOSURE: Mr. Rice has shown by careful experiment that the assumption that the phenomena described in the above mentioned paper was due to segregation, is open to question. After listening to Mr. Rice's discussion of this paper, further experimental work has confirmed his results in that it was found that there was no difference in the acid resistance of the top and bottom surfaces of shallow or flat ware fired in an inverted position. This point was brought out by the writer during the discussion of the paper on the floor of the division.

The acid test used by the writer in this work was entirely qualitative, no attempt at quantitative determinations being made. A quantitative test, similar to that used by Mr. Rice, on ware which showed a decided difference in its acid resistance under the qualitative test, would be of considerable interest, and the writer hopes to secure such data for presentation in the near future.

Mr. Rice's conclusion that the results secured by the writer "may be due more to the nature of the gases in contact with the enamel surface or the degree of volatilization taking place, than to the segregation of the soluble constituents," is in harmony with all the writer's observations, both on glass and finished ware, inasmuch as it is on deep shapes in which the gases volatil-

ized would be confined when fired in an inverted position that the difference in apparent acid resistance between inside and outside of the shape is most pronounced.

Regarding Mr. Rice's question "as to whether the bottom of a piece burned in an upright position has the same resistance on the inside as the outside of the bottom of a piece burned inverted," would say, I have found this to be the case insofar as the qualitative test would determine.

CORRECTION

Elutriation Tests on American Kaolins, by H. G. Schurecht. THIS JOURNAL **3,** 359 (1920), Line 9, and 17, for V 0.636 read $V^{0.636}$.

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General and Miscellaneous

1. What a "cost system" should do for you. ANON. *Special Rep.*, U. S. Chamber of Commerce, Fabricated Production Department.—The importance of cost accounting is discussed under the heads: Purpose and value; insurance of profits; business control; increased prod.; variations from stand. practice; control of overhead; intelligent competition; unprofitable lines; investment; and general. This and other pamphlets on the same subject will be sent on request addressed to Fabricated Prod. Dept., U. S. Chamber of Comm., Mills Bldg., Washington, D. C. ED.

2. Recent developments in spray painting. HENRY A. GARDNER. Paint Mfrs. Assoc. of U. S., *Circ.* **114,** 18 pp., Jan. 1921.—A review is given of the adaptability of spray painting to general use on interior and exterior surfaces of large area. This type of paint application will increase rather than diminish the amt. of work the master painter is called on to do, on account of the greater amt. of painting which will be stimulated by lower labor costs per job. Spray coats have been found equal to brush coats in durability. Portable spraying outfits, photomicrographs of sprayed films, etc., are illustd. F. A. WERTZ. (*C. A.*)

PATENT

3. Method of kiln setting and burning. GRAFTON E. LUCE. U. S. 1,369,752, Feb. 22, 1921. A method of setting a kiln which consists in dividing it into a plurality of horizontal portions adapted to be burned successively, the dividing means having provision for automatically changing as the burning progresses. C. M. SAEGER, JR.

Apparatus and Instruments

4. Microscopy with ultraviolet light. J. E. BARNARD. *Nature,* **106,** 378–81 (1920).—A review. W. H. ROSS. (*C. A.*)

5. A new micro combustion furnace for the determination of carbon, hydrogen and nitrogen. W. DAUTWITZ. Zürich. *Chem. Ztg.* **44,** 963 (1920).—Description, with 2 poor cuts, of a furnace which, with absorbers attached, may be clamped to a table. J. H. MOORE. (*C. A.*)

6. Effect of humidity on leather belting. F. W. ROYS. Worcester Polytechnic Inst. *Textile World J.*, **59,** 201–5 (1921).—Stretch of belting is greater for a given change in tension at high humidity than at low with a const. temp., for given change in humidity at const. temp. is greater at high tensions than at low, and is greater for given change in humidity at high temp. than at low. Curves are given. CHAS. E. MULLIN. (*C. A.*)

7. Pyrometric practice. PAUL D. FOOTE, C. O. FAIRCHILD AND T. R. HARRISON. Bur. Standards, *Tech. Paper* No. **170.**—The primary object of this volume is evidentiy to present information which is useful in the choice and operation of pyrometric installations. Enough of the underlying theory has been included to make the principle of operation of each type of instru-

ment readily understood. Special stress is laid upon refinements of construction and installation and precautions for operation. Indicating and recording instruments operated by bimetallic springs or the differential expansion of graphite and metal are considered. Several types of thermocouples are described suited to different ranges of temp. and conditions of use. The method of connecting several thermocouples to a common return wire is subject to large errors, and its use is seldom or never justified. Many wiring diagrams of typical installations are shown. Several designs of resistance pyrometers are described, as are different methods of connecting to the bulb for the purpose of minimizing or eliminating errors due to lead resistance and to resistance at dial contacts within the instrument. The leading recording instruments are shown in cuts and described in detail in the chapter on recording pyrometry. Transformation-point indicators and recorders are treated at some length, along with different methods of interpreting the data. Discussion of the control of processes through a knowledge of the temps. involved is not confined to a description of the apparatus used but enters into the broader phases of the subject. The subject of melting-point methods is treated at length. The general classes of substances considered under this heading are metals, alloys, salts, and *refractory materials*, and for the temperature measurements, thermoelectric resistance, and optical pyrometers are discussed. Where substances of known melting points are employed, the methods are equally applicable to the calibration of the pyrometers being used. Tables of melting points are given. Detailed information is presented as to the most suitable type of pyrometer to be used, the proper crucible and atmosphere for many materials, and suitable furnaces for different classes of work. Complete information is given for the calibration of all of the important high-temp. measuring instruments which are used industrially, and suitable app. and accessories are described for each type of calibration. The method for welding thermocouple junctions, the method of calculation of cold-junction corrections, and methods of procedure to avoid errors in the use of cold-junction compensators are considered in detail. In the section on ind. applications of pyrometry no attempt is made to give all the applications. Some of the applications which offer peculiar difficulties are considered. In this connection are treated the applications of pyrometry to *glass manufacture, glass annealing, rotary portland cement kilns, ceramic processes*, coke manufacture, and steel manufacture. In an appendix are given conversion tables from Fahrenheit to Centigrade and vice versa, and other useful data. H. F. S.

8. A simple portable instrument for the absolute measurement of reflection and transmission factors. A. H. TAYLOR. Bur. of Standards, *Sci. Paper* No. **405**.—The reflectometer is a sphere with a small segment cut away, leaving a hole over which the surface to be tested is placed. The wall of the sphere is viewed through a small hole by means of a portable photometer, the spot viewed being screened from the test surface. A lighting tube, set at an angle to the sphere surface, is arranged to rotate about an axis normal

to the surface of the sphere, so that the direct light can be thrown on the test surface or on the sphere wall. The theory of the integrating sphere shows that the reflection factor of the test surface is simply the ratio of the photometer readings in the two cases, no assumption being made as to the way in which the light is reflected from the test surface. Moreover, the reflection factor measured is not affected by selective reflection by the sphere walls. No accurate voltage adjustment of the lamps in the photometer and the reflectometer is necessary, as both operate from the same battery. The use of a low-voltage flashlight lamp in the lighting tube makes the instrument very portable and convenient. By the addition of an exterior light source the same instrument can be used to measure transmission factors of clear or diffusing media. H. F. S.

See also Abstr. Nos. 42, 64.

Refractories and Furnaces

9. Laboratory melting furnace with electrical heating. HANS HECHT. *Chem.-Ztg.*, **44,** 956 (1920).—A vertical alundum tube furnace with a resistor of powdered carbon and a vertically adjustable table for supporting the 600-cc. crucible. The crucible may be tapped, in place, if desired, the charge flowing out through the hollow supporting column of the table. 150 A. at a 110 V. gives temps. up to 1700°C. ED.

See also *Keram Rundschau*, **29,** 69-70 (1921).

10. The industrial use of pulverized fuels. H. DROUOT. *Technique moderne*, **12,** 407–17, 476–9 (1920).—A review of the merits of pulverized coal, of the various systems devized for handling and feeding it (Holbeck, Quigley, Fuller, Bergman, Covert, Aéro, Stroud, Lopulco), and of the various uses to which it has been put (stationary boilers, waste-heat boilers, locomotives, metallurgical furnaces of all kinds, blast furnaces, roasting of Fe ores, marine boilers, and internal-combustion engines), together with a brief mention of pulverized lignite and pitch, and colloidal fuel. A. P.-C. (*C. A.*)

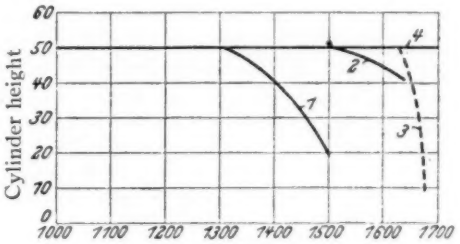
11. Grindle system of burning powdered coal. ANON. *Iron Age*, **106,** 1614–5 (1920); cf. *Ibid.*, **104,** 444 (1919).—New features of the Grindle system, including conveying and control, are described. J. L. W. (*C. A.*)

12. Pulverized coal an effective means of fuel economy. ANON. *Elec. Rev.* (*Chicago*), **78,** 134 (1921).—A review. Fuels not available for other uses may be burned effectively in powdered form. Vast resources in low-grade coals become available. C. G. F. (*C. A.*)

13. Colloidal fuels, their preparation and properties. S. E. SHEPPARD. Research Laboratory, Eastman Kodak Co., Rochester, N. Y. *J. Ind. Eng. Chem.*, **13,** 37–47 (1921); cf. *C. A.*, **14,** 1026, 1027, 2406, 3313–4.—The article comprizes a discussion of colloids and of the properties of colloidal fuel, essentially, as far as that fuel is concerned, the material covered by the abstracts cited. ARTHUR G. WILLIAMS. (*C A.*)

14. The case for colloidal fuel. LINDON W. BATES. *Chem. Age (London)*, **3,** 558–9 (1920); cf. *C. A.*, **14,** 1026, 1027, 2406, 3313–4, and the preceding abstract.—The subject matter of this article is covered by the abstracts cited. ARTHUR G. WILLIAMS. (*C. A.*)

15. The behavior of refractory brick under load at high temperatures. K. ENDELL. Berlin. *Z. Stahl u. Eisen*, No. **1** (1920).—An eye-beam 4-m. long was employed as a lever arm to apply a load of 1 kg. per sq. cm. to a refractory cylinder 5 cm. diam. and 5 cm. high, the pressure being applied by a hard carbon rod. A pointer moving over a scale indicated expansion,



contraction and deformation. A carbon resistance furnace with a free working space 12 cm. in diam. was employed. Temps. were determined to ±10° with a Holborn-Kurlbaum op. pyrom. sighted through an opening in the side of the furnace. The *results* are shown in the table and figure.

BEHAVIOR OF VARIOUS REFRACTORIES UNDER LOADS OF 1 KG. PER SQ. CM. AT HIGH TEMPERATURES

Material	Melting point °C.	Max. furnace temp. °C.	Deformation temp. °C.	Deformation Mm.	Heating time: Total	Heating time: Above 900°	Remarks
Fire-clay	1730	1500	1300	30	4h 30′	3h	The cylinder exhibits lateral expansion due to homogeneous deformation.
Magnesite	>2000	1650	1500	10	4h 45′	3h 30′	Circular fracture with little deformation.
Silica brick	1750	1680	1650	broken	4h 10′	2h 50′	The compression takes place in jumps, the broken pieces showing little deformation.

Carbon brick	>2000	1720	No deformation	4h 55′	3h 25′	No deformation but 4% shrinkage due to loss of carbon and bond from combustion and volatilization.

ED.

16. Refractories for electric furnace. R. M. HOWE. *Chem. Met. Eng.*, **23,** 1215–8 (1920).

Material	Fusion Point °C.	* Point of failure under 50 lbs./sq. in. load, °C.	Thermal Conductivity at 1000° C.	Specific heat at 100° C.	Resistance to spalling
Fire-clay	1700	1350–1400	0.0039	0.199	good[3]
Silica	1700	1600[1]	.0044	.219	poor[3]
Magnesia	2165	1480	.0079	.231	poor[3]
Chrome	2050	1425	.0057	...	poor[3]
Bauxite	1785	1350 or more	Same as fire-clay	...	good[3]
Zirconia	2575	1510[2]	low[3]	...	...
Carborundum	2240	above 1650	.0231	.186	good[3]
Alundum	2050	above 1550	high[3]	.198[1]	good[3]

* A pressure of 25 lbs. per sq. in. is usually applied at present in making these tests.

[1] Estimated from known data.

[2] Average of results with 25 lbs. and 75 lbs. per sq. in.

[3] Private communication.

Refractories should be laid up with a material similar to the brick themselves, or one which will not corrode or flux them, using as small a joint as possible. The furnace should be constructed so that heat will be conducted away from the hotter portions, using water cooling if necessary. The ratio of heating to cooling area should be made as low as possible. Refractory brick or shapes should be heated from one side only in order to keep the heating surface low and in order to avoid the effectof pressure at high temperatures. Insulation lowers the margin of safety and should, therefore, be avoided, even to the extent of not allowing dust to accumulate on the roof. Heating of the furnace should be done gradually, especially where magnesite and silica brick are involved. When the furnace is being cooled it should be remembered that cold blasts produce or accelerate spalling. H. F. S.

17. Moore rapid "Lectromelt" furnace. R. D. THOMAS. *J. Am. Inst. Elec. Eng.*, **39,** 1038–9 (1920).—The special features of the Moore furnace are: Melting is very rapid, 1/2 to 3/4 hr. per charge, roofs have long life, av. 200 heats; power consumption is low, 350 kw. hr. per ton, the *inverted dome bottom holds refractories in place,* no mechanism in pit; conducting arms also support

electrodes, thereby lessening deterioration. It is claimed that this furnace has doubled the daily output of the av. elec. furnace of the same capacity.
O. A. HOUGEN. (*C. A.*)

18. High-grade talc for gas burners. J. S. DILLER, J. G. FAIRCHILD AND E. S. LARSEN. *Econ. Geol.*, **15,** 665–73 (1920).—The production and imports of talc for the purpose mentioned are briefly discussed. The talc thus used is usually found in metamorphic limestone and in some instances in altered basic igneous rocks. Domestic deposits at Hewitts, N. C., and in Harford County, Md., and foreign deposits in Germany, France, Italy and India are described. Chem. analyses are given for material from each locality. Microscopic examn. shows chlorite to be the most abundant associate, usually from 3 to 15%. Compn. is the most important factor in detg. its suitability for gas tips. Fineness and uniformity of texture follow in importance. In these the German talc excels others; it is the product of chem. action during contact metamorphism, and no similar deposits are known in the U. S.
A. B. PECK. (*C. A.*)

19. An improved air heater. F. J. W. BELTON. *Chem. Trade J.*, **67,** 646 (1920).—An app. comprizing a number of similar parts or sections built side by side, and one upon another, and placed between end sections containing air transfer passages, and the inlet and outlet between sideplates. Air enters at the top, passing in streams at high velocity back and forth in horizontal channels, meeting the products of combustion from the gas burners which rise through narrow vertical ducts between several air channels, while suitable horizontal ribs project into the vertical ducts thereby giving the gases a circuitous path. Each vertical section is a portion of two air-heating channels at each side of the portion of gas duct. The structure is held as a unit by bolts clasping the flanges upon the end and side sections. The projecting edges form a good joint with the parts of the sections which seat thereabout preventing products of combustion gaining access to the air space of the heater. The gas burners which extend the width of the app. may be high- or low-pressure type. An exptl. run gave a thermal efficiency of 87.5%.
W. H. BOYNTON. (*C. A.*)

20. Core-baking ovens electrically heated. J. L. JONES. *Elec. Rev.*, **78,** 132–4 (1921); cf. *C. A.*, **15,** 46.—A new thermostat consists of a strip of porous refractory material impregnated with a material, nonconducting up to a given temp. but conducting above it. The strip is supported by Ag terminals and connected to a suitable relay, motor-driven switch and a small transformer. The impregnating Material (not divulged) regulates the temp. required for core-oven work and is capable of controlling temps. from 65° to 800°. The wt. of core plates should be reduced to a minimum consistent with stiffness. Tables show percentages of various ingredients in core materials and the strength of cores made under various conditions in electrically heated ovens. (*C. A.*)

PATENTS

21. Glass pot furnace. MAURICE MATHY. Leige, Belgium. U. S. 1,369,453, Feb. 22, 1921. A crucible glass furnace or oven comprising a plurality of separate crucible chambers, the bottom of each chamber being formed with cavities, a crucible in each chamber, fragments of porous refractory material surrounding the crucible and filling the cavities, gas and air supply ducts at the basis of the cavities, a regenerator for each chamber for effecting the heating of the air for combustion, a number of glass-holes, a duct connecting each of the glass-holes with the air supply duct of the chambers, and fusible closing means in the connecting ducts.

22. Tunnel-kiln and method of operating of same. PHILIP H. DRESSLER. U. S. 1,369,330, Feb. 22, 1921.—The method of operating a tunnel-kiln which consists in maintaining an atmosphere formed by a hot body of gaseous material in a central portion of the kiln chamber without substantial movement of the atmosphere except for convection current circulation thereof and blowing gaseous material into the end of the kiln along the top of the kiln chamber so as to create a downward flow of the kiln atmosphere between the end and center of the kiln with a return flow along the bottom of the kiln toward the kiln end, and the escape therefrom of the excess gaseous material passed into the kiln chamber whereby the maintenance of an unduly high top temperature in the end of the kiln by reason of the convection current circulation of the kiln atmosphere is prevented,

23. Tunnel-Kiln. PHILIP D'H. DRESSLER. U. S. 1,366,369, Jan. 25, 1921. A tunnel kiln having an elongated kiln chamber comprising a heating zone and a goods cooling zone at one end of the heating zone, and having an air preheating and goods cooling conduit extending along the cooling zone, and a combustion chamber separated by a heat conducting wall from the kiln chamber extending along the heating zone thereof, the improvement which consists in a fan or blower having its inlet connected to the cooling zone conduit and its outlet connected to the combustion chamber whereby pressure differentials tending to create leakage flow between the kiln chamber and the combustion chambers or conduit may be minimized.

24. Tunnel-kiln. ARTHUR T. SHEPARD. U. S. 1,366,424, Jan. 25, 1921. A tunnel kiln with longitudinally extending masonry benches at the sides of a pathway at the bottom of the kiln for goods carrying means and having mounted on each of the benches an elongated combustion chamber, pipes connected to and forming an extension of the combustion chamber, and a header to which the ends of the pipes remote from the combustion chamber are connected, each bench being formed with a channel having uprising end portions which communicate one with the interior of the header and the other with the interior of the combustion chamber at the opposite ends of the pipes and with an outlet from the channel for products of combustion, and dampers regulating the relative amounts of products of combustion passing from the

combustion chamber to the outlet through the pipes and a portion of the channel, and through the by-paths about the pipes formed by the remaining portion of the channel. C. M. SAEGER, JR.

25. Furnaces. H. STRACHE. Brit. 152,668, Oct. 19, 1920. A process and app. for the combustion of fuel in furnaces with the recovery of by-products consists in supplying the fuel to the furnace through one or more pipes, chambers or passages in which the fuel is coked and gasified by the heat from the furnace, the coke being fed onto the furnace grate and the gases withdrawn from the coking chambers mixed, if desired, with combustion products and delivered to app. for sepg. the by-products, the residual gases being returned to the furnace. A suitable app. is specified. (*C. A.*)

See also abstract Nos. 39, 41, 76; also Book Reviews.

Chemistry, Physics and Geology of Raw Materials

26. On the transformation of quartz into tridimite. O. REBUFFAT. *Chem-Zentr.*, **23,** 643 (1920); *Giorn. die Chin. ind. ed appl.*, **2,** 437–8 (Aug. 1920).—Observation of the behavior of silica brick when burned seems to indicate that the presence of small amts. of P_2O_5 favors the formation of tridimite.

WM. M. CLARK.

27. Swelling phenomena in fibrous alumina. HEINZ V. ZEHMEN. *Kolloid-Z.*, **27,** 233–5 (1920).—Both the "fibrous alumina" (H. Wislicenus, *Z. angew. Chem.*, **17,** 805 (1904)) as prepared by E. Merck, and the so-called "sprouted alumina" (*C. A.*, **1,** 2038) which is ignited and therefore converted into Al_2O_3 and freed from Hg, behave like reversible gels, resembling the gels of SiO_2 and ZrO_2 (studied especially by van Bemmelen) in their adsorption and loss of water. Dehydration between 100 and 200° proceeds gradually, each temp. corresponding to a certain water content. The Merck prepn. loses 6.5% at 100°, a further 3% at 150°, and 2–3% at 200°. On exposure to the air this mosture is regained to within about 1% (hysteresis), 10% within one day and the rest after 5–6 days. After several weeks in an atm. satd. with H_2O vapor, the water adsorption may equal 60%. The swollen fibrous *clay* shows a marked increase in vol. and adsorbs much more Congo red than would be expected from its Al_2O_3 content, in some cases over double, which seems to be due to the increase in the active internal surface accompanying dispersion. JEROME ALEXANDER. (*C. A.*)

28. Note on crucibles used in rock analysis. HENRY S. WASHINGTON. *J. Wash. Acad. Sci.*, **11,** 9–13 (1921).—For Na_2CO_3 fusions a crucible made of Pt-Ir has proved more satisfactory than one of pure Pt because it is less liable to indentation and susceptible of a higher polish, so that fused cakes are easier to remove. For several mos. a Pd-Au crucible has been used for these fusions and has proved even more satisfactory. The av. loss in wt. after each Na_2CO_3 fusion is about 0.2 mg. or only about half as much as with a Pt-Ir crucible. W. T. H. (*C. A.*)

29. Survey of the physics and chemistry of colloids. THE SVEDBERG. *Chem. Met. Eng.*, **24,** 23–7 (1921).—A review. JEROME ALEXANDER. (*C. A.*)

30. New method for the determination of potassium in silicates. JEROME J. MORGAN. Columbia Univ., New York. *J. Ind. Eng. Chem.*, **13,** 225–7 (1921).—Digest 0.3–0.6 g. of the silicate with excess of HF, evap. to dryness, add 25 cc. 3 N HCl and warm until all except small amt. of CaF_2 dissolves. Add 10 cc. of 10% $HClO_4$ and evap. to dense white fumes and finally (on a special low temp. elec. heated sand bath) to dryness. Take up residue with hot water, add 1 to 2 cc. of the 10% $HClO_4$ and repeat the above evaporation as many times as may be necessary to give a residue completely soluble in hot water. The residue from the final evap. is allowed to cool, 20 cc. of 97% alc., containing 1 cc. of 60% $HClO_4$ per 300 cc., is added, and the mixt. is stirred and digested for 15 min. Filter cold through an asbestos Gooch, wash with the alc. soln (30–50 cc. sufficient) dry at 130° C and weigh the pure $KClO_4$ thus obtained. If sulphates of the alk. earth metals are present, dissolve the weighed $KClO_4$ in hot water, dry the Gooch at 130° and weigh again. The sulphates will remain on the filter after this treatment and can thus be corrected for. ED.

31. The mechanics of solidity. REGINALD G. DURRANT. *Nature*, **106,** 440–1 (1920); cf. Innes, *C. A.*, **15,** 194.—Hardness is due in part to closeness of at. packing, and diversities in hardness depend also on how far each substance tested is removed from its melting point. *Coeffs. of expansion* themselves depend partly on how far the mean range of temp. from which they are calcd. is removed from the m. p. For strict comparison "corresponding temps." should be taken. If this is done for coeffs. of expansion of gases, then the values become identical; with solids the coeffs. should approach but never reach uniformity. W. H. ROSS. (*C. A.*)

32. Thermal conductivity of some solid insulators. J. R. CLARKE. *Phil. Mag.*, **4,** 502–4 (1920).—The relation proposed by Thornton (*C. A.*, **14,** 682) that the thermal cond. of a substance is equal to the product of the coeff. of elasticity and the d. is tested by the data for a number of Jena glasses. No agreement is found. S. C. L. (*C. A.*)

33. Clay, report on the clays worked by the Longwood Tessellated Tile Co., Ltd., at Longwood. L. KEITH WARD. S. Australia Dept. of Mines, *Mining Review*, **32,** 38–40 (1920).—The clays worked here consist of residual clays resulting from the weathering or the underlying slate. Most of the clay is iron stained, but by careful selection clay can be obtained which will burn almost white. It is thought that part of the clay is suitable for stoneware, though at present the mfgs. consist mainly of flooring tile with subordinate amts. of roofing tile and common brick. Some of the clay is highly siliceous and could possibly be used for refractory purposes.

D. D. SMYTHE

34. A microscopic study of vein quartz. SIDNEY F. ADAMS. Stanford Univ. *Econ. Geol.*, **15,** 623–64 (1920).—The study is confined to veins of hydrothermal origin and to chalcedony and quartz, the most common varieties of silica in veins. (I) A. describes the varieties found in the different types of veins, gel structures, and structures developed in quartz crystd. in free space. The common chalcedony type is cryptocryst., in spherical, botryoidal, and similar structures. These are usually inherited from a gel state. Fibrous chalcedony is also described. Chalcedony is usually found only in deposits formed near the surface, and is almost invariably subordinate to quartz. Normal quartz is found in all ranges of deposition. Anomalous varieties, feathered and flamboyant, are found only in low-pressure deposits and may be accessory or prominent. Deep-seated veins characteristically consist of interlocking aggregates of normal quartz crysts. in uniform structure. Superficial veins show diversity of structure—crustification in banded, comb, cockade, and spheroidal structure, and colloform structures in microcryst. quartz and chalcedony. Uniformity and lack of it characterize deep seated and shallow veins, respectively. (II) Replacement quartz, replacement structures in fissure veins, and effects of pressure on quartz. Replacement quartz is usually anhedral except when the structure is inherited from the previous mineral, such as easily sol. minerals as calcite. This leads to lamellar or radial structures of the quartz. Pressure results in uneven extinction, various inclusion patterns, shredded quartz due to extreme shearing, and recrystn. of quartz by molecular rearrangement in a crystal to relieve its strained condition. The latter is absent in deposits formed near the surface and its presence may be taken as indicating formation at depth. Many excellent photographs are included. A. B. PECK. (*C. A.*)

35. Kaolin of Indiana. W. N. LOGAN. Ind. State Dept. of Conservation, *Bull.* **6** (1920); *Econ. Geol.*, **15,** 542 (1920).—The beds occur at or near the top of the Mississippian in several counties in the S. W. part of the state. All beds have sandstone above and shale below. Only slight com. development has taken place to date, although large quantities of high-grade white clays are present. The discussion covers the physical and chem. properties of the kaolin, geological conditions of occurrence, origin, uses, and distribution by counties. Earlier explanations of origin are disproved. Lab. expts. and microscopical examn. show that the origin is biochemical. Certain S bacteria are believed to be able to secrete kaolin. The S bacteria obtain S from pyrite in the shale. H_2SO_4 formed attacks the shale and the resulting compd. reacts with quartz of the sandstone, S being replaced by SiO_2, forming kaolin. A. B. PECK. (*C. A.*)

36. Glass sand. Glass sands of Kentucky. C. H. RICHARDSON. *Ky. Geol. Survey*, [6] **1,** 1–149 (1920).—The first half of the rept. is devoted to a general discussion of glass, its properties, classification, raw materials and methods of mfg. Following this comes a description of the glass sands of Ky., which are divided into three geog. groups. In the last 40 pages are given

anal. of sands from the previously described deposits, anal. of fluxes suitable for use in the mfg. of glass and a bibliography dealing with the more imp. works on glass sands and the glass sand ind.

37. Barite. Dept. of Mines, S. Australia, *Mining Review*, **31,** 90 (1920).—An extensive deposit of good barite is found at Pernatty Lagoon near Uvocalla, S. Australia. The occurrence is in crystals and blocks associated with gypsum in clay. A considerable quantity has been obtained and sold but the deposits are not being worked at present.

38. Clay. The clays and shales of Virginia, west of the Blue Ridge. H. RIES AND R. E. SOMERS. Va. Geol. Survey, *Bull.* **20,** 1–118 (1920).—This rep. is the third and final no. in a ser. dealing with the clay resources of Virginia. The first few pages are devoted to a short discussion of the geol. occurrences and phys. props. of clays in gen. For discussion in detail, the clays are grouped according to geol. formations. In each of these groups the deposits are divided according to counties and then described individually. These descriptions give both the geol. features and the phys. tests of the clays.

39. Graphite. Dept. of Mines, S. Australia, *Mining Review*, **31,** 18, 52–6 (1920).—A bonus of 1 ' per ton is offered on marketable graphite produced from any mine in S. Australia and sold prior to June 30, 1922. Development work is being continued by the Uley Graphite Syndicate. It is stated that there are 5000 tons of 11% ore blocked out and 10,000 tons of "probable" ore.

40. Mica. The geology of the Lomagundi mica deposits. H. B. MAUFE. S. Rhodesia Geological Survey, *Short Rep.* **10,** 1–8 (1920).—This recently opened field, covering an area of over 40 sq. miles, lies along the W. flank of the Angwa river basin in the N. central part of the Lomagundi district. The country rock is principally a mica schist with a few outcrops of various igneous rocks. The merchantable mica occurs in pegmatite dikes varying in width from a few inches to as much as 45 ft. The books of mica occur in the pegmatite along the contact with the mica schist, or surrounding horses of mica schist included in the pegmatite. In places the books are in contact with each other. The mica is entirely muscovite, the books of which vary in length from 4 or 5″ to as many feet but seldom exceed a thickness of 6″. Thus far the mica has been extracted from open cuts having a max. depth of 35 ft. The feldspar of the dike is decomposed so that in most cases the extraction is made without the aid of powder. The mica is sorted and trimmed on the ground by the natives, only the trimmed mica being shipped as yet. As the av. yield is 1.5 lbs. trimmed mica from ea. 100 lbs. mined, a great deal of waste, which as yet is not being utilized, is accumulating.

D. D. SMYTHE.

See also Book Reviews.

Whiteware and Porcelain

41. Maximum temperature allowable for insulation. ANON. *Elec. World*, **77,** 154 (1921).—Tests for heating should be made at the rated voltage, frequency, and load for which the app. is rated under conditions equiv. to operating conditions. The three methods are: detn. of the temp. by Hg or EtOH thermometers, by resistance thermometers, and by thermocouples or resistance temp. detectors applied to the hottest accessible parts. Tables give the permissible temps. and hottest spot corrections for insulating materials of different classes, also the temp. coeffs. for Cu.

W. H. BOYNTON. (*C. A.*)

42. The mechanical properties of porcelain and exact methods for determining same. E. ROSENTHAL AND F. SINGER. *Chem. Zentr.*, **24,** 675 (1920); *Elektrotechn. Z.*, **41,** 705–6, 9/9.—Porcelain insulators must meet mechanical conditions as well as having the desired elec. props. Authors claim to have developed a hammer, swinging as a pendulum, for applying a definite shock test to porcelain which gives comparative readings.

WM. M. CLARK.

43. Suspension type of transmission line (porcelain) insulators. ALFRED STILL. *Elec. Rev.*, **78,** 135–8 (1921); cf. *C. A.*, **15,** 472.—This instalment covers the design and construction of porcelain suspension insulators; discussion of advantages of thick porcelain in suspension insulators, etc.

C. G. F. (*C. A.*)

44. Chemical pottery. J. W. MELLOR. *Pottery Gaz.*, **46,** 245–7 (1921).—The success of many chem. industries often depends upon the ability of the porcelain to withstand chemicals. The body usually consists of 2 parts clay, 1 part feldspar and 1 part flint. Vitrified ware is best suited to withstand the action of chemicals. Porous ware even when glazed is unsatisfactory since the glaze may crack or peel or contain pinholes. Glazed porcelain, however, enables ppts., etc., to be easily removed. The glaze should have as near the coef. of expans. of the body as possible, thus reducing the tendency of the body to break when subjected to sudden temp. changes. A thin glaze would produce smaller strains than a thick glaze. Salt glazes produce less strains than sprayed glazes. The mechan. strength of ceramic bodies is not nearly as high as that of metal, hence reinforcement with metal bands is often desirable.

45. Translucency and the resistance of porcelain to firing. TH. HERTWIG-MÖHRENBACH. *Sprechsaal*, **54,** 1–2 (1921).—The acid and alkali contents of a number of porcelain bodies were varied. Small boxes (with lids) were then cast and their color, translucency and resistance to deformation observed after firing.

1. 0.65 K_2O 0.35 CaO, ZnO	2.8 Al_2O_3, 14 SiO_2	This body has 12.7% shrink., is highly translucent and retains

		Acid ratio 1 : 1.49	its shape well
2.	0.8 K_2O 0.2 CaO, ZnO	2.8 Al_2O_3, 17 SiO_2 Acid ratio 1 : 1.8	This body looses its shape badly in firing
3.	0.8 K_2O 0.2 CaO, ZnO	2.8 Al_2O_3, 18 SiO_2	This body looses its shape more than No. 2
		Acid ratio 1 : 1.91	
4.	0.83 K_2O 0.17 CaO, MgO, FeO	3.59 Al_2O_3, 16.36 SiO_2	This body retains its shape well at cone 14
		Acid ratio 1 : 1.38	
5.	0.65 K_2O 0.35 CaO, MgO, FeO	3 Al_2O_3, 11 SiO_2	This body retains its shape well but is not translucent

Increasing the Al_2O_3 and SiO_2 contents in porcelains decreases the translucency and increases the resistance to deformation. The following glaze is recommended for cone 9 porcelain:

$$\left.\begin{matrix}0.2\ K_2O\\ .2\ MgO\\ .5\ CaO\\ .1\ ZnO\end{matrix}\right\}\ 0.5\ Al_2O_3,\ 4\ SiO_2$$

With body 1 and this glaze a high class porcelain may be made at cone 9.

H. G. SCHURECHT

Brick and Tile

46. Sand-lime brick—description and specifications. ANON. Bur. of Standards, *Circ.* No. **109.**—Sand-lime brick were first produced in the United States in 1901. By the action of steam under pressure, the lime is caused to combine with some of the sand, forming a hydrated calcium silicate. This material acts as a bonding agent to hold the rest of the sand together. Most sand-lime bricks will compare favorably with "first common" clay bricks. They are characterized by their straight edges, parallel faces, and nearly white color. Sand-lime brick is not a refractory material. A good sand-lime brick for general purposes should have an absorption of not over 20%, an average comp. strength of not less than 2000 lbs. per sq. in., and an average modulus of rupture of not less than 450 lbs. per sq. in. H. F. S.

PATENTS

47. A brick-drier. CHARLES H. KLEIN. U. S. 1,368,940, Feb. 15, 1921. A drier, comprising an alleyway having hollow side walls formed with a plurality of ducts connected with a suitable source of forced drying medium, a car movable into and out of the alleyway with its sides adjacent to but spaced from the side walls, the car having a tier of superimposed pallets spaced upwardly apart and adapted to hold pallets of spaced bricks thereon, the ducts being arranged in the opposite side walls of the alleyway to form separate superimposed strata of drying medium across the spaces between the superimposed pallets so that the drying medium is forced across the

lowermost space, between a pair of pallets immediately above and so on back and forth across the spaces between the pallets from the bottom to the top of the car and finally exhausting outwardly above the car.

48. Method of and means for supporting tiles, more especially while subject to heat treatment. PHILIP D'HUC DRESSLER. London, England. U. S. 1,368,219, Feb. 8, 1921. The method of treating tiles, consisting in arranging the tiles with their surfaces vertical to form a plurality of horizontal rows of tiles and supporting the rows of tiles in superposed parallel sets, the edges of the tiles being inclined to the horizontal and the horizontal rows of tiles in one set being arranged in staggered relationship and parallel to those in an adjacent set.

49. Tile-sorting machine. BRADLEY L. BENSON. U. S. 1,369,377, Feb. 22, 1921. · An apparatus having a series of parallel inclined worms having their lower ends positioned beneath the hopper, a device for raising and lowering the end of the hopper, a rotating brush mounted within the hopper for the purpose of regulating the flow of the tile therefrom, guides mounted beneath the worms, a device causing the tile to be sorted to ride upon the guides, a cam carried on the end of each of the worms, vacuum cups positioned between the ends of the worms, an arm carried on each of the vacuum cups and adapted to engage one of the cams, the vacuum cup being adapted to engage the smooth surface of the tile delivered by the worms, and withdrawing therefrom for the purpose of proper distribution and means for releasing the tile so engaged from the vacuum cup.

50. Manufacture of hollow tile and the like. FRANK DOCHNAL. U. S. 1,369,522, Feb. 22, 1921. A method of making hollow tile which is to be finally used as open end tile, which consists in forcing through a die, providing a temporary end wall tie section, or sections, of the tile with a plurality of lines of slotted perforations for weakening the end of the wall tie section, or sections, so they may be easily broken out by the tap of a convenient tool after being burnt and prior to being laid into a wall structure.

C. M. SAEGER, JR.

Glass

51. Scientific glassware made at Vineland, N. J. *Glassworker*, **40,** 19 (1921); from Vineland *Daily Republican.*—The plant covers 9 acres, has 7 furnaces and employs 700 workers. A gen. description is given of the methods of making chem. ware, lab. app. and thermos bottles. Most of these products replace those imported from Germany and Austria before the war.

52. Various methods of silvering of glass. *Glassworker*, **40,** 19 (9121).—The method of H. Halle (*Handbuch der Praktischen Optik*) is given in full detail. Also the method used by Brashear and an improved method by M. Schair is given.

53. Hints on the melting of watch glasses. *Schnurpfeil's Review for Glass Works*, **4,** 767 (1921).—Three qualities are made, finest, medium and ordinary. Satisfactory batches are given. 1st grade, sand 100, potash 35, lead 35, saltpetre 5, lime 10, manganese 1/4. 2nd grade, sand 100, potash 35, barytes 10, lime 10, saltpetre 3, arsenic 1/2, manganese 1/4. 3rd grade, sand 100, potash 17, soda ash 17, saltpetre 2, lime 14, arsenic 1/2, manganese 1/4. The glass must be absolutely free from bubbles, blown into large balls of correct curvature and uniform thickness. After annealing the watch-glass panes are cut out and finished.

54. Composition of selenium ruby glass. Schnurpfeil's *Review for Glass Works*, **4,** 771 (1921).—Sand 100. soda ash 42, borax 12, lime 8, selenium 1.25, cadmium sulfide 1.75. Used for lantern globes.

55. Composition of glass for lamp chimneys. Schnurpfeil's *Review for Glass Works*, **4,** 771 (1921).—Sand 100, soda ash 33, lime 10, lead 6, barytes 6, borax 1, saltpetre 2, manganese 0.25.

56. A glass etching ink. Schnurpfeil's *Review for Glass Works*, **4,** 771 (1921).—Take 2 parts HF, 2 parts NH_4F and 2 parts precipitated $BaSO_4$ and rub together in a china mortar. Transfer to a lead cup, add fuming HF and stir with gutta-percha rod. R. J. MONTGOMERY.

57. Transmission and refraction data on standard lens and prism material with special reference to infra-red spectroradiometry. W. W. COBLENTZ. Bur. Standards, *Sci. Papers* **401,** 701–14 (1920); *J. Optical Soc. Am.*, **4,** 432–47 (1920).—Optical consts. are given for *glass*, CS_2, quartz, fluorite, rock salt, and sylvite. A classified bibliography is added. W. F. MEGGERS. (*C. A.*)

58. Decolorization of glass by metallic selenium. SABURÔ TSUBOI. Dainihon Yôgyô Kyôkwai Zasshi. *J. Soc. Jap. Ceram.*, **338,** 44–7 (1920).—By addition of 0.003–0.005 Se to 5000 soda glass, the latter is tinged with a beautiful rose color splendid in transparency. Fifty parts of glass are decolorized by 0.02 As_2O_3, 0.003 Se, and 0.001 Co flint, without leaving any dark shades. The color does not change on annealing. K. K. (*C. A.*)

59. Some applications of the photoelectric (selenium) cell to practical photometry. W. E. STORY, JR. *Trans. Ill. Eng. Soc.*, **15,** 827–47 (1920).—The photoelec. cell seems capable of easy adaptation to measuring the c. p. of incandescent lamps in factories. Diagrams of arrangements for this purpose are shown and discussed. The cell used was made according to the procedure of Kunz. D. MACRAE. (*C. A.*)

60. Calculations for glass raw materials and batches. L. SPRINGER. *Die Glashütte*, **50,** 787 (1920).—Information regarding selenium compounds; S and S compounds; As_2O_3 and Sb_2O_3; nitre and nitre substitutes; equivalence of potash and soda nitre.

61. Calculations for glass raw materials and batches. L. SPRINGER. *Die Glashütte*, **49,** 771 (1920).—Covers compounds of Co, Ni, Cu, Ag, Au and U, grades found on the market and proportions to use.

62. Calculations for glass raw materials and batches. L. SPRINGER, *Die Glashütte*, **48,** 759 (1920).—Covers SnO_2; federweiss (talcum); coloring, decolorizing and clarifying agents; Fe, Mn, and Cr compounds.

63. Pyrex glass. ANON. *Chem. Zentr.*, **23,** 643 (1920); *Chem. Weekblad*, **17,** 465 (11, 9).—Physical constants are stated as d. 2.25; coeff. of elasticity 6230 kg/mm²; refractive index 1.4754; linear coeff. of expans. (19–350°) 0.0000032; sp. ht. 0.20; thermal cond. 0.0027; softening temp. 750°.

64. Marking Glass Vessels. *Punde Chem. Zentr.* **24,** 657 (1920). Permanent marking on glass or porcelain is produced by scratching the surface with a sharp aluminum point and in this manner vessels may be calibrated in the laboratory.

65. Sodium silico-fluoride and phosphate opacifying agents. L. SPRINGER. *Glashütte*, **46,** 723–4 (1920).—Calculations of equivalence of different sources of fluorine in glass are shown together with examples of substituting other sources of alumina and fluorine to replace cryolite. Similar exposition is given of the diff. raw materials and equiv. of sources of phosphoric acid.

66. Technical heat consultation office of the German glass industry. ANON. *Glashütte*, **47,** 740–1 (1920).—Incorporated advisory and standardizing bureau founded by the Assoc. of German Glass Ind., Frankfurt. Describes the purposes of this new coöp. bureau for improving fuel conditions in the glass ind. by the utilization of low-grade fuels and endeavoring to derive the utmost attainable thermal effect from all commercial fuel sources.

67. On the annealing temperature of glass. F. WEIDERT AND G. BERNDT. *Chem. Zentr.*, **23,** 642 (1920); *Z. f. Tech. Phys.*, **1,** 51–8.—Annealing temp. is defined as that temp. at which the movement of the molecules is so great that the internal stresses in glass immediately vanish, *i. e.*, (the Maxwell time of relaxation is very small). Six glasses from the Sendlinger optical works were examined (two crown, two flint, two Ba glasses) so that the difference of refractive index of the ordinary and the extraordinary rays (which furnish a a measure of the internal stresses) could be measured after cooling through a series of temps. between 200 and 600°C. If the relation of the stresses after and before cooling are plotted as ordinates and the temp. of disappearance as abscissas we obtain for each glass a hyperbolic curve with a sharp bend a definite temp. (the annealing temp.) and which proceeds further horizontally or (owing to incipient devitrification) begins to rise again. The position of the sharp bend is found to be independent of the size of the piece, and, within certain limits, of the method of cooling. The temps. were compared with Schulz's softening temp. and with Zschimmer's cohesion temps. The former, which has only theoret. significance, signifies that temp. to which a glass must at least be chilled so that its internal stresses

are infinitely large. The cohesion temp. signifies that temp. at which two superimposed glass plates weld together. It is a function of the size of the piece, the kind of surface contact, and especially of the time of heating; for a period of 30 min. it approaches the softening temp. as has been shown with a series of Jena glasses. The annealing temps. of the Sendlinger glasses of the same optical properties (and approx. of the same chem. compn.) lies about 70 to 110°C lower than the softening temps. of Jena glasses. The deformation temps. of the Sendlinger glasses were determined, *i. e.*, the temperature at which, on the polished surface, a prism (with a 25 mm. edge) placed on edge and one-half embedded in kiesselguhr made an impression. After 6 hours heating the first impression was noted. This averaged about 30°C lower than the cohesion temp.; for the flint glasses about 40 to 50°C lower and of the four remaining glasses about 70 to 110°C higher, than the annealing temps. The order of increasing deformation temps. for these glasses is the same as the order of increasing annealing temps. These are characteristics of the special types of glasses but are also functions of the temp. intervals and sizes of pieces. For a prism with a 50 mm. edge (about eight times the mass) the temp. is about 40 to 50°C lower while an increase to a 75 mm. edge produced no further change. WM. M. CLARK.

PATENTS

68. Glass forming machine. CLYDE R. LOTT. U. S. 1,369,679, Feb. 22, 1921. An apparatus having a blank mold, a sliding bottom movable lengthwise of the mold and forming a closure for the mold during such movement, and a forming device at the opposite end of the mold and coöperating therewith for forming a blank during the inward movement of the bottom, the forming device being brought into its operative position in the mold before the inward movement of the bottom.

69. Glass. MAURICE A. SMITH. U. S. 1,365,797, Jan. 18, 1921. A glass having low coefficient of expansion and high resistance to high and low temps., the glass being made from a batch consisting of a preponderance of silica, smaller amounts of B_2O_3, Al_2O_3, $NaNO_3$, and Na_2CO_3, and still smaller amounts of $CaCO_3$ and As_2O_3.

70. Glass-molding. FREDERICK W. MILLER. Hockley Heath, England. U. S. 1,368,958, Feb. 15, 1921. A method of molding consisting in fusing powdered or comminuted material in a metal mold thereby causing the fused material to adhere to the mold, and dissolving the mold from the fused material

71. Method of gripping and cutting sheet glass. HUDSON S. CAMPBELL. U. S. 1,367,858, Feb. 8, 1921. The method of cutting glass consisting in nicking the glass while in a plastic condition, and subsequently heating the glass along the line of the nick.

72. Glass-casting table. WILLIAM J. GOLIGHTLY. U. S. 1,366,786. Jan. 26, 1921. A plate glass casting table, foundation means therefore,

transversed bars between the foundation means and the table, and adjusting screws at the ends of the bars for applying force thereto, tending to lift the table.

73. Glass-furnace. ALEXANDER FRANZ PEETERS. Leerdam, Netherlands. U. S. 1,366,745, Jan. 25, 1921. A glass furnace comprising a single melting compartment, and a pair of separate working compartments diverging from one end of the melting compartment and being in permanent, free communication with the melting compartment both above and below the glass level, the longitudinal axes of the working compartments forming angles of considerably less than 90° with the longitudinal axis of the melting compartment; the two side walls of each working compartment being formed with working openings.

74. Process of preventing the accumulation of moisture in drops on glass sheets. JOSEPH H. T. ROBERTS. Meols, England. U. S. 1,369,708, Feb. 22, 1921. The process consists in covering the glass sheet with a transparent gelatinous substance which will absorb the water and prevent its accumulation in drops, and leaving the covering unprotected.

75. Process for manufacture of white clouded glasses, enamels and glazes. EDUARD RITZ. Sao Paulo, Brazil. U. S. 1,366,101, Jan. 18, 1921. The manufacture of white clouded glass, enamels and glazes, which comprises embodying unpurified clouding material in the glass, glaze or enamel with material containing sufficient fluorin to prevent discoloring.

76. Method for making glass melting pots. JOHN A. BECHTEL. U. S. 1,366,861, Jan. 25, 1921. The method of forming clay pots which consists in compacting the clay in a form having the contour of the exterior of the pot to be formed and comprising a plurality of vertical sections, coring out the center portion of the massive clay to form the interior of the pot, and then removing a section of the form intermediate between the top and bottom sections thereof to permit the pot to shrink during the drying operation with the top and bottom sections in position. C. M. SAEGER, JR.

See also abstract Nos. 21, 32, 36.

Cement, Lime and Plaster

77. Colored wall plaster. W. E. EMLEY AND C. F. FAXON. Bur. of Standards, *Tech. Paper* No. **181.**—The plaster is made of calcined gypsum, wood fibre, and other ingredients. By the use of wood fibre dyed with aniline dyes, a fast-colored gypsum plaster can be made. After this has been applied to the wall and allowed to set, the surface may be scrubbed with soap and water, thereby exposing the colored fibres. Beautiful effects may be produced by the variation of color by the use of fibres of different sizes, by different proportions of fibre and by different surface treatments. The finished wall can be scrubbed with soap and water as frequently as desired. H. F. S.

PATENTS

78. Cement-kiln. JOHN NELSON. U. S. 1,366,586, Jan. 25, 1921. A kiln comprising spaced annular walls having a downdraft chamber therein communicating with the space between the walls adjacent to the bottom of the kiln and a baffle plate spirally connected between the walls forming an updraft flue outletting adjacent the top of the kiln.

79. Portland-cement and calcining kiln. JOHN NELSON. U. S. 1,366,585. Jan. 25, 1921. An apparatus for the manufacture of cement comprising an upright furnace, gas rings in furnace adapted for heating the interior thereof, a stack upon the open top of the furnace adapted for the deposit of pulverized ingredients therein, a screen across the bottom blade for the ingredients carried by the shaft of the motor above the screen whereby the ingredients are evenly fed through the latter for descent by gravity through the heat zone of the kiln whereby the ingredients are calcined into cement.

C. M. SAEGER, JR.

80. Making portland cement. R. W. LESLEY. Brit. 152,106, July 4, 1919. The hot waste gases from a rotary cement kiln are used to heat retorts containing low-grade carboniferous materials such as oil shale, lignite, low-grade bituminous or cannel coal, etc. The volatile products from the retorts may be passed along a pipe and burned in the kilns or may be used for other purposes, and the ash or residue is added to the calcareous or other ingredients and submitted to the clinkering process, the C in the residue forming a part at least of the fuel required in the process. The ash or residue from the retorts is carried by a conveyor to a hopper to which the cement-making materials are supplied, and the mixt. is passed therefrom into the kilns. The kilns are heated initially by fuel supplied by a pipe. Cf. 11,618, **1891**.

(*C. A.*)

BOOK REVIEWS

Graphite. HUGH S. SPENCE. Canad. Dept. of Mines, Mines Branch, Rep. No. 511. Pp. 202 and LVI plates. Ottawa, 1920.—This rep. is a general treatise on the subject of graphite with special reference to the Canadian deposits, mining and milling methods. Chaps. I, II, and III deal with the history, origin, composition and economic importance of graphite. Chapt. IV is devoted to graphite in Canada and gives individual descriptions of the various deposits including numerous maps. Chapt. V covers the field of the concentration and refining of graphite, showing numerous flow sheets and diagrams of machinery from mills in the United States and Canada. Chapt. VI disposes of artificial graphite while Chapt. VII deals with the various uses of graphite. In Chapt. VIII statistics of canadian graphite production are given. Chapt. IX is a discussion of foreign graphite deposits. The last chapter (X) is devoted to a discussion of the methods used in the analysis of graphite and is followed by a bibliography and index. At the end are a number of plates illustrating raw and manufactured graphite, graphite mines, and mills.

D. D. SMYTHE

ACTIVITIES OF THE SOCIETY

Minutes of Meeting Held by Members of American Ceramic Society, for the Purpose of Forming a Heavy Clay Products Division of the Society

Meeting held March 8 at 10 A.M., in Room 1011, Hotel Deshler, Columbus Ohio. Meeting called to order by Mr. F. H. Riddle, acting Chairman—Mr. C. F. Tefft appointed temporary Secretary by Mr. Riddle, until permanent officers could be selected. Fifty members of the Society were present at the meeting.

Organization.—Voted that the Members of the American Ceramic Society assembled in this meeting, organize a Division of the Society under the name of Heavy Clay Products Division—the definition of this term and scope of work to be outlined by a Committee of Five, to be appointed by the Chair.

Voted that the above Committee of Five have power to select and appoint a permanent Chairman and Secretary, the appointment to be made and officers installed at afternoon session, to be held at 2 P.M. in the same location as present meeting. Chair appointed on this Committee the following men: Mr. M. W. Blair, Chairman, Mr. R. K. Hursh, Mr. M. P. Post, Mr. A. V. Bleininger, Mr. Fred Brand.

Reading of Papers.—Reading of paper by Mr. M. W. Blair, "Technical Investigation or Practical Application." Discussion on this paper by Mr. Riddle, Mr. Stevens, Mr. Blair, Sr.

Reading of paper by Mr. R. F. Geller, "The Water Smoking of Clays." Discussion on this paper by Mr. M. W. Blair and Mr. R. K. Hursh.

Discussion of Scope of Work for Heavy Clay Products Division

Mr. Bleininger gave a very interesting talk outlining the program to be followed in research work for the Heavy Clay Products Manufacture. It is planned to devote energies at present to the burning problem. Mr. Blair, Sr., made a very strong appeal to the members present on the advisability of getting a much larger appropriation from the Government for Ceramic Research Work. It appears that the farmers in this country are able to obtain appropriation close to $30,000,000 per year for experimental work to help improve their crops, while the Ceramic field is able to obtain an appropriation of only $3,000,000 per year. Mr. Bleininger, formerly of the Bureau of Standards and Mr. Moore of the Bureau of Mines stated that they would be only too glad to assist in any way possible to get larger appropriations for their work.

Reading of Correspondence from Members not Present.—Reading by Secretary of letters from two members expressing good will toward organization

of Division and regretting their inability to help by their presence. Letters were from Mr. J. R. Thomas, of Standard Brick Company, Crawfordville, Ind., and Mr. E. W. Dailey, of North Iowa Brick and Tile Company.

Adjournment.—Adjourned until 2 P.M.

Minutes of the Afternoon Meeting of the Heavy Clay Products Division of the American Ceramic Society

Meeting held in same room as morning session.

This meeting was called to order at 2 P.M. by Mr. M. W. Blair, Chairman of the Committee of Five, who were to report on the appointment of permanent officers for the Division. Mr. Blair reported the appointment of Mr. R. C. Purdy as permanent Chairman and Mr. C. F. Tefft as secretary. These officers were then installed.

Report of Committee follows: "It is the sense of this Committee that the activities of the Heavy Clay Products Division shall embrace the following interests unless otherwise provided for in the Society rulings: Face Brick, Paving Brick, Common Brick, Hollow Building Tile, Promenade and Quarry Tile, Sewer Pipe, Drain Tile, and any other lines that may properly be included in this Division.

"It is expected that the Division shall act as a clearing house and publicity medium for the information to be derived from the technical investigations proposed to be financed by the Associations actively controlling the above lines. It is urged that insofar as possible the investigations to be undertaken, shall be interpreted and applied in such a way as to be immediately available upon the respective plants represented.

It is also urged that membership be solicited particularly among the men in active charge of manufacturing operations and that they be encouraged in every way to prepare and present papers and discussions for the programs of this Division, dealing with their every day tasks and problems."

VOTED: To adopt this report.

Mr. Purdy in his acceptance of the appointment as Chairman outlined a probable plan of procedure for the next year and stated most clearly that if this Division were to be a success, all of the members must give their support and answer any questionnaires which may be sent them, as complete records from actual practice will be a big help in the work that is planned.

VOTED: That the Chairman appoint a Membership Committee to be made up of at least one member from each of the various industries represented by the Heavy Cay Products Division,—the Chairman of this Committee to be a member of the American Ceramic Society's Membership Committee. Chair announced that this Committee would be appointed later.

Mr. Blair, Sr., again brought up the matter of more financial support from our Government to help in the ceramic industries which are being planned. A discussion of this subject was carried on by Mr. Greenough who felt that we should get more definite information as to just what is planned and the amount of money necessary to carry out the plans before asking for larger appropriations.

VOTED: That the Chair appoint a Committee of Three with power to consider rules and draft a set of by-laws for this Division. The Chair asked for time to consider the appointment of this Committee.

Mr. Stevens called the attention of everyone present to the need of our getting the papers and reports of investigations into the most simple language so that they could be understood by the men at the plants.

Mr. Purdy suggested the best way to get the information contained in these reports to the foreman was to have heart to heart talks with them and study the papers over carefully at these meetings.

Adjourned.

C. FORREST TEFFT, *Secretary*

Actions Taken by the Board of Trustees

March 22. It was voted that the next Annual Meeting of the Society be held at the Hotel Statler, St. Louis, February 27–March 2, 1922.

It was voted that the Board of Trustees authorize the Committee on Publications to appoint a Board of Associate Editors of the JOURNAL.

It was voted to discontinue the membership held in the National Fire Protection Association.

New Members Received During March, 1921

Resident Associate

Austin, G. L., Joliet, Ill., Superintendent, American Refractories Co.

Bitting, A. W., 3344 Michigan Ave., Chicago, Ill., Director of Research, Glass Container Association of America.

Blackburn, C. A., Cleveland, Ohio, General Superintendent "Ivanhoe Plant" Cleveland Metal Products Co.

Burton, R. C., Zanesville, Ohio, President, Burton-Townsend Co.

Clark, Ernest, Terra Cotta, Ill., Superintendent, American Terra Cotta & Ceramic Co.

Cushman, H. D., 1101 Swetland Bldg., Cleveland, Ohio, President, Ferro Enameling Co.

Dana, Leslie, St. Louis, Missouri, President, Charter Oak Stove & Range Co.

Davis, S. E., 929 Division St., South Parkersburg, W. Va., General Porcelain Co.

Earl, Oliver N., Box 97, East Liverpool, Ohio, Harshaw, Fuller & Goodwin Co.

Edson, S. P., Bryantville, Mass., Superintendent and Enameler, Wheeler Reflector Co.

Elledge, H. G., 3384 Webster Ave., Pittsburgh, Pa., Technical Assistant to General Sales Manager, Diamond Alkali Co.

Ewing, R. F., 1602 Clark Ave., Wellsville, Ohio, McLain Fire Brick Co.

Forsyth, J. H., Cleveland, Ohio, Associate Chemist, Glass Technology Dept., National Lamp Works of G. E. Co.

Frazier, C. E., Washington, Pa., President, Simplex Engineering Co.

Frey, Wm. J., 304 W. Adams St., Sandusky, Ohio, Superintendent, Universal Clay Products Co.

Gernon, Ursula F., Brookings, S. D., Craft Instructor, South Dakota State College.

Greenough, Maurice B., 830 Engineers Bldg., Cleveland, Ohio, Secretary, National Paving Brick Manufacturers Association.

Krekel, Albert, 1917 W. Fayette St., Baltimore, Md., Engineer, Porcelain Enamel & Mfg. Co.

Langworthy, H. S., Jewettville, N. Y., Vice-President and Superintendent, Jewettville Clay Products Co.

Little, H. B., Baltimore, Md., President, Baltimore Enamel & Novelty Co.

McGee, Earle N., Syracuse, N. Y., Research Laboratory, Semet-Solvay Co.

Marshall, S. M., 1107 Broadway, New York City, Consulting Engineer, Perin & Marshall.

Metz, G. F., 120 Broadway, New York City, Sales Engineer, Hardinge Co.

Miller, Emerson R., Zanesville, Ohio, Salesman, Mosaic Tile Co.

Minehart, A. G., Jr., Toledo, Ohio, Manager, The Rock Products Co.

Mitchell, Leon W., Rock Island, Ill., Superintendent, Rock Island Stove Co.

Nye, C. P., Uniontown, Pa., Manager, Richmond Radiator Co.

Raiff, David A., Coshocton, Ohio, Enameler, Beach Enameling Co.

Riblet, Bertha, 2047 East 115th St., Cleveland, Ohio.

Riley, R. J., Indianapolis, Ind., Indianapolis Terra Cotta Co.

Rogers, Thomas L., Chicago, Ill., Special Representative, National Silica Co.

Shaw, Lucian, West Lafayette, Ohio, Secretary, The West Lafayette Manufacturing Co.

Theobald, Erwin F., Magnolia, Ohio, Ceramic Engineer, National Fire Proofing Co.

Vance, Edward D., Springfield, Ohio, Ceramic Engineer, Safety Emery Wheel Co.

Vodick, William J., Libertyville, Ill., Chicago Hardware Foundry Co.

Weaver, James P., Box 658, Belle Vernon, Pa., Chemist, American Window Glass Co.

Webster, Henry, 628 Lexington Ave., Newport, Ky., Kiln Expert, Henry Webster & Sons.

Wenning, W. F., Pittsburgh, Pa., Research Dept., Vitro Manufacturing Co.

Williams, C. W., 720 Electric Bldg., Cleveland, Ohio, Harshaw, Fuller & Goodwin Co.

Williams, George A., 173 Johnson Ave., Tottenville, S. I., N. Y., Chemist Atlantic Terra Cotta Co., Perth Amboy, N. J.

Worsham, Edgar A., Baltimore, Md., Assistant Treasurer, Porcelain Enamel & Manufacturing Co.

Foreign Associate

Clare, H. L., Hespeler, Ontario, Canada, Sales Manager, Stamped & Enameled Ware.

Cronshaw, H. B., Ph.D., Brierley Hill, South Staffordshire, England, Principal Technical Institute.

Erdmann, K., Radenthein, Kaernten, Austria, General Director, Austro-American Magnesite Co.

Parkinson, Caleb, Ashdale, Holmfield, Halifax, Yorkshire, England, Manager, Parkinson & Spencer, Ambler Thorn Fireclay Works.

Saito, Hachiro, Omuta, Japan, Chief Engineer, Miike Chemical & Dye Works.

Shaluvalia, Dogar Singh, Stoke-on-Trent, England, Hollin Minton Patent Tile Works.

Stein, Alan, Bonnybridge, Scotland, Managing Director, John G. Stein & Co., Ltd.

Tatsumi, Eiichi, Omuta, Japan, Superintendent, Miike Chemical & Dye Works.

Corporation

Acme Brick Co., 412 Adams Bldg., Danville, Ill.
McLain Fire Brick Co., 508 Fulton Bldg., Pittsburgh, Pa.
Matawan Tile Co., Matawan, N. J.
Mitchell Clay Mfg. Co., 5627 Manchester Ave., St. Louis, Mo.
Old Bridge Enameled Brick & Tile Co., Old Bridge, N. J.
Pennsylvania Pulverizing Co., Lewistown, Pa.
Salem China Co., Salem, Ohio.
The Stark Rolling Mill Co., Canton, Ohio.
Universal Clay Products Co., Sandusky, Ohio.
The Wahl Co., 1800 Roscoe St., Chicago, Ill.

NECROLOGY

Jacob Hasslacher, well known in ceramic circles, died at his home, 322 West 100th Street in the City of New York, on the morning of March 15, 1921, in the 69th year of his age,

Among his friends he was recognized as farseeing and broad in his views and purposes, forceful but tactful, willing at all times to subordinate his own wishes to the good of the cause he supported, liberal to give his friendship, effort and means, sympathetic, an ardent lover and admirer of nature. After many years of active administration in chemical industry he was on account of ill health and to the great regret of his associates compelled to retire from active participation about a year ago. Despite his retirement he maintained an active interest in all his former friends and their activities until a few days before his death.

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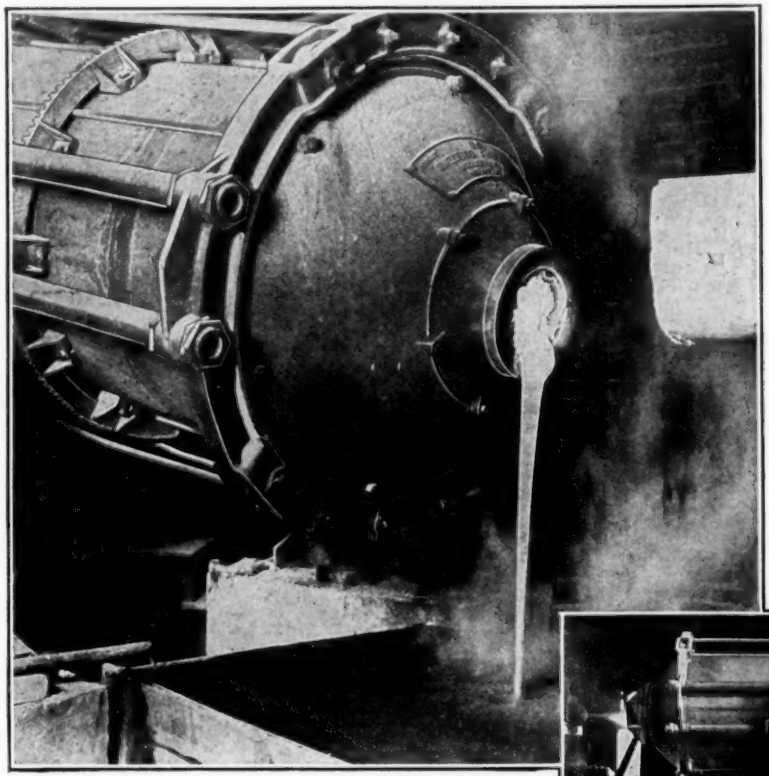

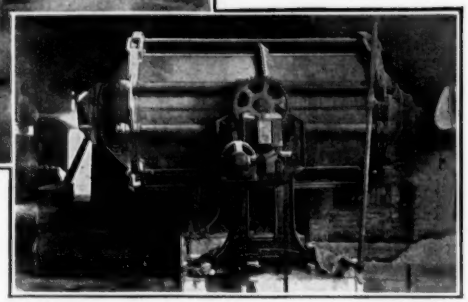

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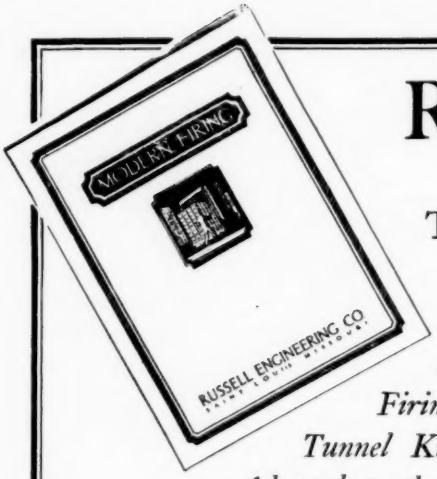

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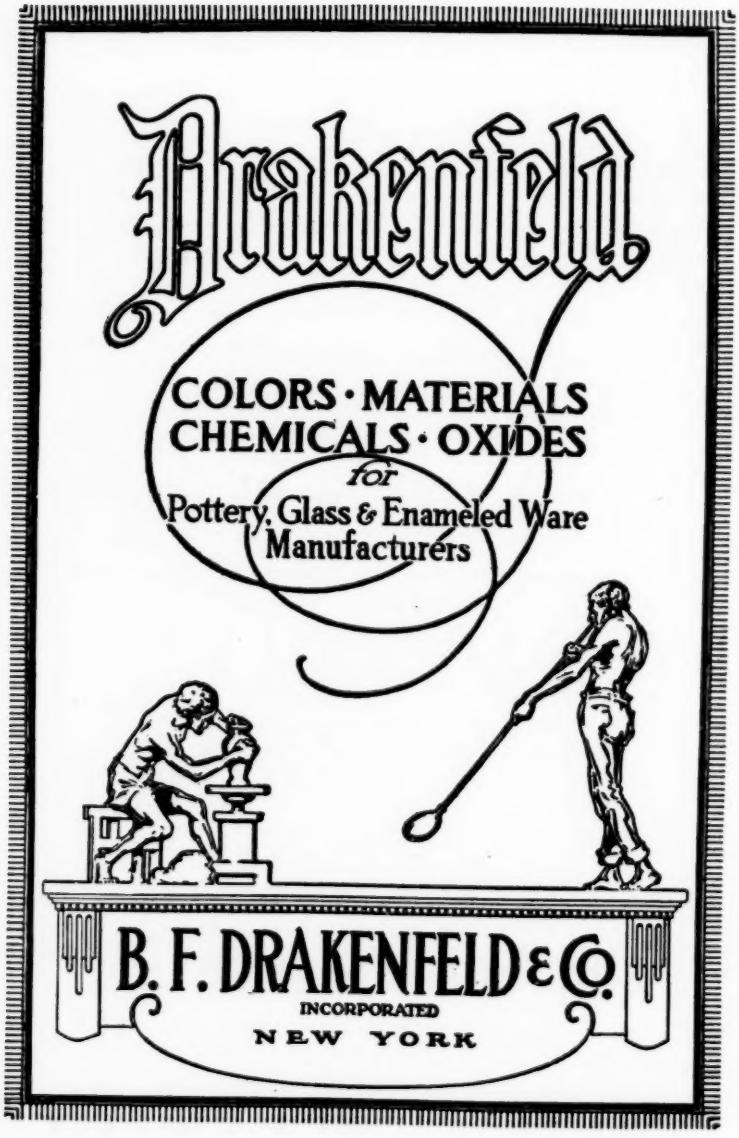
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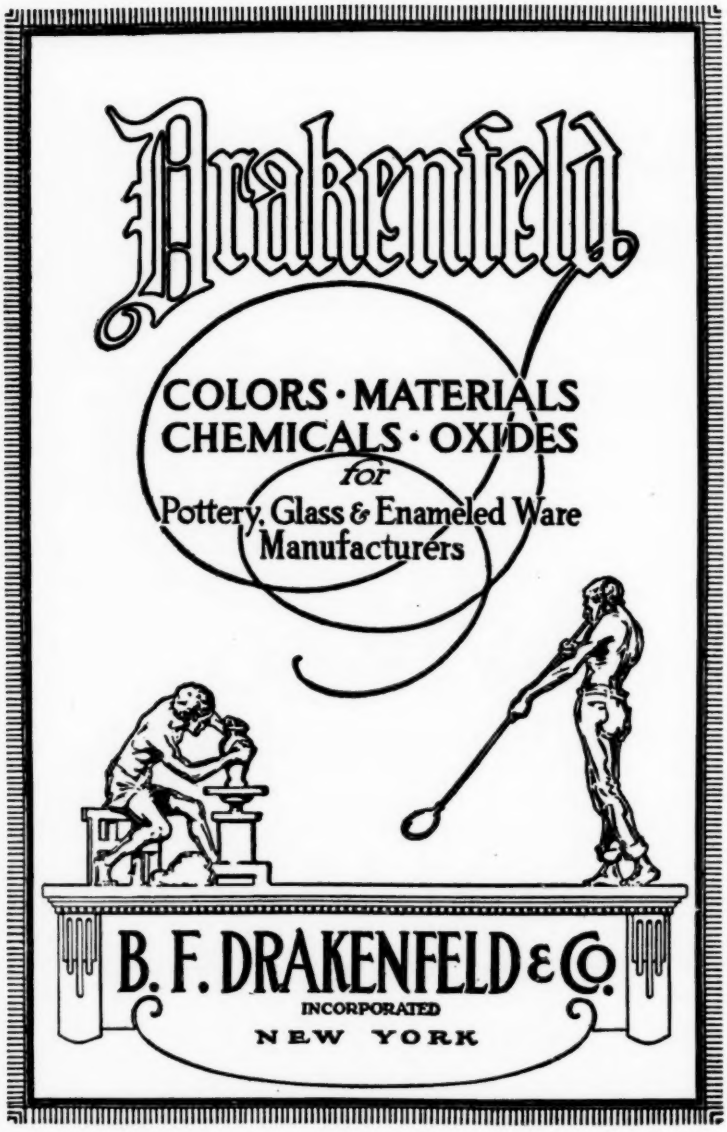
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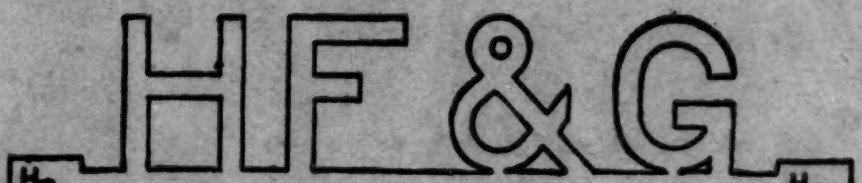

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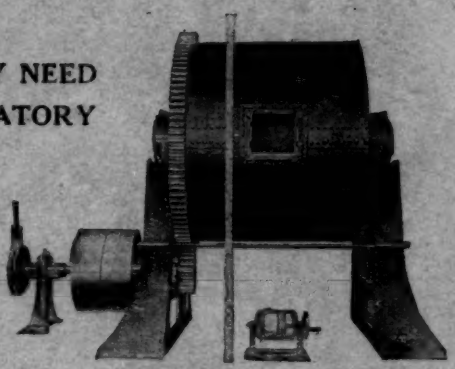

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